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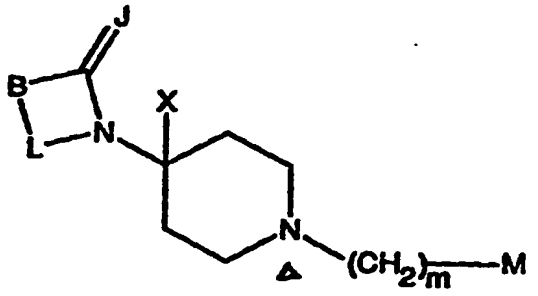
(54) Title: NOVEL 4-PIPERIDINYL SUBSTITUTED LACTAMES AS NEUROKININ 2 RECEPTOR ANTAGONISTS FOR THE TREATMENT OF ASTHMA

(57) Abstract

Compounds of formula (I), wherein J, B, L, X m and M have any of the meanings given in the specification, their N-oxides, and their pharmaceutically acceptable salts are nonpeptide antagonists of neurokinin A and useful for the treatment of asthma, etc. Also disclosed are pharmaceutical compositions, processes for preparing the compounds of formula (I) and intermediates.



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NOVEL 4-PIPERIDINYL SUBSTITUTED LACTAMES AS NEUROKININ 2 RECEPTOR ANTAGONISTS FOR THE TREATMENT OF ASTHMA

This invention concerns novel lactam derivatives, and, more particularly, novel 4,4-disubstituted piperidines, in which one of the substituents is a lactam derivative bonded at its nitrogen, which antagonize the pharmacological actions of one of the endogenous neuropeptide tachykinins known as neurokinins, particularly at the neurokinin 2 (NK2) receptor. The novel lactam derivatives are useful whenever such antagonism is desired. Thus, such compounds may be of value in the treatment of those diseases in which an NK2 receptor is implicated, for example, in the treatment of asthma and related conditions. The invention also provides pharmaceutical compositions containing the novel lactam derivatives for use in such treatment, methods for their use, and processes and intermediates for the manufacture of the novel lactam derivatives.

The mammalian neurokinins comprise a class of peptide neurotransmitters which are found in the peripheral and central nervous systems. The three principal neurokinins are Substance P (SP), Neurokinin A (NKA) and Neurokinin B (NKB). There are also N-terminally extended forms of at least NKA. At least three receptor types are known for the three principal neurokinins. Based upon their relative selectivities favoring the neurokinin agonists SP, NKA and NKB, respectively, the receptors are classifed as neurokinin 1 (NK1), neurokinin 2 (NK2) and neurokinin 3 (NK3) receptors, respectively. In the periphery, SP and NKA are localized in C-afferent sensory neurons, which neurons are characterized by non-myelinated nerve endings known as C-fibers, and are released by selective depolarization of these neurons, or selective stimulation of the C-fibers. C-Fibers are located in the airway epithelium, and the tachykinins are known to cause profound effects which clearly parallel many of the symptoms observed in asthmatics. The effects of release or introduction of tachykinins in mammalian airways include bronchoconstriction, increased microvascular permeability, vasodilation and activation of mast cells. Thus, the tachykinins are implicated in the pathophysiology and the airway hyperresponsiveness

observed in asthmatics; and blockade of the action of released tachykinins may be useful in the treatment of asthma and related conditions. Peptidic NK2 antagonists have been reported. For example, a cyclic hexapeptide known as L-659,877 has been reported as a selective NK2 antagonist. Nonpeptidic NK2 antagonists also have been reported, for example in European Patent Application, Publication Number (EPA) 428434, EPA 474561, EPA 512901, EPA 512902, EPA 515240, EPA 559538, as well as in WO 94/10146. I have discovered a series of nonpeptidic NK2 antagonists, and this is the basis for my invention.

According to the invention, there is provided a Compound of the invention which is a compound of formula I (formula set out hereinbelow following the Examples, together with other formulae denoted by Roman numerals) wherein

X is (1-6C)alkyl, $-CH_2OR^a$, $-CH_2SR^a$, $-CH_2S(=O)R^g$, $-CH_2S(=O)_2R^g$, $-C(=O)R^a$, $-C(=O)OR^a$, $-C(=J^a)NR^bR^c$, $-C(R^a)(OR^d)(OR^e)$, $-CH_2N(R^a)C(=J^a)R^f$, $-CH_2N(R^a)C(=O)OR^f$ or $-CH_2N(R^a)C(=J^a)NR^bR^c$;

B is a direct bond and L is a hydrocarbon chain in which the 1-position is bound to B and L is selected from trimethylene, tetramethylene, cis-1-butenylene and cis,cis-butadienylene; or B is $N(R^h)$ and L is a hydrocarbon chain selected from ethylene, trimethylene and cis-vinylene; or B is N and L is a hydrocarbon chain in which the 1-position is bound to B and L is cis,cis-prop-2-en-1-ylidin-3-yl;

J and J^a are independently oxygen or sulfur;

R^a, R^f and R^h are independently hydrogen or (1-6C)alkyl;

R^b and R^c are independently hydrogen or (1-6C)alkyl in which said (1-6C)alkyl may be substituted by a group selected from hydroxy and (1-3C)alkoxy, or said (1-6C)alkyl may be terminally substituted by a group selected from hydroxy, (1-3C)alkoxy, phenyl, $-C(=O)OR^i$ and $-C(=O)NR^jR^k$; or

R^b and R^c together with the nitrogen to which they are attached form a pyrrolidino, piperidino, morpholino, thiomorpholino (or its S-oxide) or piperazinyl group (which piperazinyl group may bear a methyl or ethyl group at the 4-position);

R^d and R^e are independently (1-3C)alkyl or together form a divalent hydrocarbon chain selected from ethylene and trimethylene;

R^g is (1-6C)alkyl;

R^i, R^j and R^k are independantly hydrogen or (1-3C)alkyl;

m is 2 or 3;

M is a residue of formula Ia or formula Ib wherein

Q is phenyl which may bear one or two substituents independently selected from halo, trifluoromethyl, hydroxy, (1-3C)alkoxy, (1-3C)alkyl and methylenedioxy; or Q is thienyl, imidazolyl, benzo[b]thiophenyl or naphthyl any of which may bear a halo substituent; or Q is biphenylyl; or Q is carbon-linked indolyl which may bear a benzyl substituent at the 1-position;

Q^a is hydrogen, (1-4C)alkyl, or a radical of formula $-(CH_2)_q-NR^7R^8$ in which q is 2 or 3 and R^7 and R^8 are independently (1-4C)alkyl or NR^7R^8 is piperidino or 4-benzylpiperidino;

R^3 is hydrogen, methyl or (2-6C)n-alkyl which may bear a terminal amino radical;

R^4 is $-C(=O)R^5$, $-C(=O)OR^5$ or $-C(=J^1)NHR^5$ in which J^1 is oxygen or sulfur and R^5 is hydrogen, (1-6C)alkyl, phenyl(1-3C)alkyl (in which the phenyl may bear one or more halo, hydroxy, (1-4C)alkoxy or (1-4C)alkyl substituents), pyridyl(1-3C)alkyl, naphthyl(1-3C)alkyl, pyridylthio(1-3C)alkyl, styryl, 1-methylimidazol-2-ylthio(1-3C)alkyl, aryl (which may bear one or more halo, hydroxy, (1-4C)alkoxy or (1-4C)alkyl substituents), heteroaryl (which may bear one or more halo, hydroxy, (1-4C)alkoxy or (1-4C)alkyl substituents), or (when R^4 is $-COR^5$) α-hydroxybenzyl;

n is 0, 1, 2 or 3;

p is 1 or 2, and when p is 2, n is 1 and J^2 is two hydrogens;

J^2 is oxygen or two hydrogens;

L^1 is carbonyl or methylene;

r is 0, 1, 2, or 3; and

R^6 is phenyl which may bear one or more halo, trifluoromethyl, (1-4C)alkyl, hydroxy or (1-4C)alkoxy substituents (and particularly one or more chloro or fluoro substituents); naphthyl which may bear one or more halo, trifluoromethyl, (1-4C)alkyl or hydroxy substituents; pyridyl; thienyl; indolyl; quinolinyl; benzothienyl or imidazolyl; or when L^1 is carbonyl, the group

$-(CH_2)_r-R^6$ may represent aryl, heteroaryl or a benzyl group bearing an α-substituent selected from hydroxy, (1-4C)alkoxy and (1-4)alkyl, and further wherein the aryl, heteroaryl or phenyl portion of the benzyl group may bear one or more substituents selected independently from halo, trifluoromethyl, (1-4C)alkyl, hydroxy and (1-4C)alkyl, hydroxy and (1-4C)alkoxy (and particularly one or more chloro or fluoro substituents);

or the N-oxide of the piperidino nitrogen indicated by Δ;

or a pharmaceutically acceptable salt thereof;

or a quaternary ammonium salt thereof in which the piperidino nitrogen indicated by Δ is a quadricovalent ammonium nitrogen wherein the fourth radical on the nitrogen R^9 is (1-4C)alkyl or benzyl and the associated counterion A is a pharmaceutically acceptable anion.

A subgroup of the invention is a compound of formula I as defined above, wherein, R^b and R^c are independently hydrogen or (1-6C)alkyl; or R^b and R^c together with the nitrogen to which they are attached form a pyrrolidino, piperidino, morpholino, thiomorpholino (or its S-oxide) or piperazinyl group (which piperazinyl group may bear a methyl or ethyl group at the 4-position); or the N-oxide of the piperidinio nitrogen indicated by Δ; or a pharmaceutically acceptable salt thereof; or a quaternary ammonium salt thereof.

Another subgroup of the invention is a compound of formula Ic; or the N-oxide of the piperidinio nitrogen indicated by Δ; or a pharmaceutically acceptable salt thereof; or a quaternary ammonium salt thereof; wherein J, B, L, X, Q, R^9 and A have any of the values defined above for a compound of formula I.

It will be appreciated that a compound of formula I (or Ic) contains one or more asymmetically substituted carbon atoms such that such a compound may be isolated in optically active, racemic and/or diastereomeric forms. A compound may exhibit polymorphism. It is to be understood that the present invention encompasses any racemic, optically-active, diastereomeric, polymorphic or stereoisomeric form, or mixture thereof, which form possesses NK2 antagonist properties, it being well known in the art how to prepare optically-active forms (for example, by resolution of the racemic form or by synthesis from

optically-active starting materials) and how to determine the NK2 antagonist properties by the standard tests described hereinafter. It may be preferred to use the compound of formula I (or Ic) in a form which is characterized as containing, for example, at least 95%, 98% or 99% enantiomeric excess of the form which is of the (S)-configuration at the center indicated by * in formula Ia, Ib or Ic.

In this specification R^a, R^b, R^1, R^2, et cetera stand for generic radicals and have no other significance. It is to be understood that the generic terms "(1-3C)alkyl" and "(1-6C)alkyl" include both straight and branched chain alkyl radicals but references to individual alkyl radicals such as "propyl" embrace only the straight chain ("normal") radical, branched chain isomers such as "isopropyl" being referred to specifically. A similar convention applies to other generic groups, for example, alkoxy, alkanoyl, et cetera. Halo is fluoro, chloro, bromo or iodo. Aryl denotes a phenyl radical or an ortho-fused bicyclic carbocyclic radical having about nine to ten ring atoms in which at least one ring is aromatic. Heteroaryl encompasses a radical attached via a ring carbon of a monocyclic aromatic ring containing five ring atoms consisting of carbon and one to four heteroatoms selected from oxygen, sulfur and nitrogen or containing six ring atoms consisting of carbon and one or two nitrogens, as well as a radical of an ortho-fused bicyclic heterocycle of about eight to ten atoms derived therefrom, particularly a benz-derivative or one derived by fusing a propenylene, trimethylene of tetramethylene diradical thereto, as well as a stable N-oxide thereof.

A pharmaceutically acceptable salt is one made with an acid which provides a physiologically acceptable anion.

Particular values are listed below for radicals, substituents and ranges for a compound of formula I or formula Ic as described above for illustration only and they do not exclude other defined values or other values within defined ranges for the radicals and substituents.

A particular value for m is 2.

A particular value for (1-6C)alkyl is methyl, ethyl, propyl,

isopropyl or butyl.

A particular value for (1-3C)alkyl is methyl or ethyl.

When M is formula Ia, a particular value for Q^a is hydrogen, a particular value for R^3 is methyl and a particular value for R^4 is $-COR^5$. A particular value for R^5 is aryl, and more particularly phenyl, which aryl (or phenyl) may bear one or two chloro or fluoro substituents.

When M is formula Ib, a particular value for n is 1 or 2; a particular value for p is 1; a particular value for J^2 is two hydrogens; a particular value for L^1 is carbonyl; a particular value for r is 0 or 1; and a particular value for R^6 is phenyl which may bear one or two halo or (1-4C)alkoxy substituents, and more particularly a chloro, fluoro or isopropoxy substituent.

A particular value for Q is, for example, phenyl which may bear one or two substituents selected from halo, trifluoromethyl and methylenedioxy; and, more particularly, 3,4-dichlorophenyl or 3,4-methylenedioxyphenyl.

A particular value for R^9 is methyl or benzyl and for A is, for example, chloride, bromide or methanesulfonate.

A particular subgroup of the invention is a compound of formula Ic wherein B is a direct bond and L is a hydrocarbon chain in which the 1-position is bound to B and L is selected from trimethylene, tetramethylene, cis-1-butenylene and cis,cis-butadienylene.

Another particular subgroup of the invention is a compound of formula Ic wherein B is $N(R^h)$ and L is a hydrocarbon chain selected from ethylene, trimethylene and cis-vinylene; or B is N and L is a hydrocarbon chain in which the 1-position is bound to B and L is cis,cis-prop-2-en-1-ylidin-3-yl.

Particular values for the nitrogen linked substituent that includes L, B, and J in a compound of formula I include 2-oxo-pyrrolidino, 2-oxopiperidino, 2-oxo-1,2,5,6-tetrahydropyridin-1-yl, 2-oxo-1,2-dihydropyridin-1-yl, 2-oxo-imidazolidin-1-yl, 2-oxo-4-imidazolin-1-yl, 2-oxoperhydropyrimidin-1-yl and 2-oxo-1,2-dihydropyrimidin-1-yl.

A preferred value for X is $-C(=O)OR^a$ or $-C(=J^a)NR^bR^c$ wherein R^b and R^c independently have any of the values defined for them above other than hydrogen.

A preferred value for the nitrogen linked substituent that includes L, B, and J in a compound of formula I is 2-oxopiperidino, or 2-oxoperhydropyrimidin-1-yl.

Preferred compounds include (S)-N-[2-(3,4-dichlorophenyl)-4-[4-(methylaminocarbonyl)-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide, (S)-N-[2-(3,4-dichlorophenyl)-4-[4-(ethylaminocarbonyl)-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide, (S)-N-[2-(3,4-dichlorophenyl)-4-[4-[N-(2-methoxycarbonylethyl)aminocarbonyl]-4-(2-oxopiperidino)-piperidino]butyl]-N-methylbenzamide, (S)-N-[4-[4-(aminocarbonyl)-4-(2-oxopiperidino)piperidino]-2-(3,4-dichlorophenyl)butyl]-N-methylbenzamide, and (S)-N-[2-(3,4-dichlorophenyl)-4-[4-methoxycarbonyl-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide.

Pharmaceutically acceptable salts of a compound of formula I (or of formula Ic) include those made with a strong inorganic or organic acid which affords a physiologically acceptable anion, such as, for example, hydrochloric, sulfuric, phosphoric, methanesulfonic, or para-toluenesulfonic acid.

A compound of formula I (or of formula Ic) may be made by processes which include processes known in the chemical art for the production of structurally analogous heterocyclic compounds. Such processes and intermediates for the manufacture of a compound of formula I (or of formula Ic) as defined above are provided as further features of the invention and are illustrated by the following procedures in which the meanings of generic radicals are as defined above unless otherwise indicated:

(a) Alkylating a piperidine of formula III with an aldehyde of formula IV (or of formula IVc), by reductive alkylation. The alkylation is preferably carried out by a conventional reductive alkylation, for example as described in Example 1, by the in situ, acid-catalyzed formation of an imminum salt, followed by reduction with sodium cyanoborohydride in alcoholic solvent.

(b) Alkylating a piperidine of formula III with an alkylating agent of formula V (or of formula Vc) in which Y is a leaving group. Typical values for Y include for example, iodide, bromide, methanesulfonate, p-toluenesulfonate, trifluoromethanesulfonate, and the like. The reaction may be carried out under standard conditions, for example in a suitable solvent at a temperature in the range of -20 to 100 °C, preferably in the range of 0 to 50 °C.

(c) For an N-oxide of the piperidino nitrogen indicated by Δ of a compound of formula I (or of formula Ic), oxidizing the piperidino nitrogen indicated by Δ of a compound of formula I using a conventional procedure, such as, for example, using hydrogen peroxide in methanol, peracetic acid, 3-chloroperoxybenzoic acid in an inert solvent (such as dichloromethane) or dioxirane in acetone.

(d) For a quaternary ammonium salt of a compound of formula I (or of formula Ic), alkylating the piperidino nitrogen indicated by Δ of the compound of formula I (or of formula Ic) with an alkylating agent of formula R^9Y or alkylating a piperidine of formula IIIa with an alkylating agent of formula V, wherein Y is a leaving group, followed, if required, by exchanging the counterion Y for a different counterion A by a conventional method. Typical values for Y include those listed above under (b) for Y. Exchange of counterions may conveniently be carried out using a basic ion exchange resin in the "A" form.

(e) for a compound of formula I wherein X is defined as $-C(=O)OR^a$ and R^a is hydrogen, hydrolyzing a corresponding compound of formula I wherein R^a is (1-6C)alkyl. The reaction may be carried out under standard conditions known for the hydrolysis of esters, for example in an aqueous organic solvent optionaly employing either acid or base catalysis. For example, the reaction may be carried out under conditions similar to those described in Example 17.

It may be desired to optionally use a protecting group during all or portions of the above described processes; the protecting group then may be removed when the final compound is to be formed.

Whereafter, for any of the above procedures, when a pharmaceutically acceptable salt of a compound of formula I is required, it may be obtained by reacting the compound of formula I with an acid affording a physiologically acceptable counterion or by any other conventional procedure.

It will also be appreciated that certain of the various optional substituents in the compounds of the invention may be introduced by standard aromatic substitution reactions or generated by conventional functional group modifications either prior to or immediately following the processes above, and as such are included in the process aspect of the invention. Such reactions and modifications include, for example, introduction of nitro or halogeno and reduction of nitro. The reagents and reaction conditions for such procedures are well known in the chemical art.

If not commercially available, the necessary starting materials for the above procedures may be made by procedures which are selected from standard techniques of heterocyclic chemistry, techniques which are analogous to the synthesis of known, structurally similar compounds (particularly those described in the above noted EPA publications and their counterparts), and techniques which are analogous to the above described procedures or the procedures described in the Examples. The starting materials and the procedures for their preparation are additional aspects of the invention.

A convenient intermediate for preparation of starting materials of formulae IV, and V (or formula IVc and Vc) is an alcohol of formula VI (or formula VIc). The preparation of an optically active alcohol of formula VIc in which Q is 3,4-dichlorophenyl is described in Example 1, parts a.-h.; An alcohol of formula VI (or formula VIc) may then be oxidized to the aldehyde of formula IV (or formula IVc), for example using oxalyl chloride, dimethyl sulfoxide and triethylamine or using Dess-Martin periodinane (1,1,1-triacetoxy-1,1-dihydro-1,2-benziodoxol-3(1H)-one) as described in Example 1.i.; or it may be converted into an alkylating agent of formula V (or formula Vc) by a conventional procedure.

A convenient intermediate for the preparation of a starting material of formula III is an acid of formula II in which R^{10} is a

protecting group for the piperidine nitrogen. For example, Example 1, parts j.-k., describes the preparation of an acid of formula II in which R^{10} is a benzyl protecting group. An acid of formula II may be converted to a piperidine of formula III for example as described in Example 1, parts k.-o. for 4-ethoxycarbonyl-4-(2-oxopiperidino)-piperidine.

When a compound of formula III is required in which J is sulfur, it conveniently may be obtained from a corresponding 1-protected piperidine intermediate in which J is oxygen by treatment with phosphorous pentasulfide or with Lawesson's reagent, 2,4-bis(4-methoxyphenyl)-1,3-dithia-2,4-diphosphetane-2,4-disulfide, followed by deprotection of the piperidine nitrogen.

A starting material piperidine of formula IIIa may be obtained from a piperidine of formula III by alkylation or reductive alkylation to introduce the substutient R^9; or the compound may be prepared in a manner analogous to the preparation of a compound of formula III for example as described in Example 1, parts j.-n. for 1-benzyl-4-ethoxycarbonyl-4-(2-oxopiperidino)piperidine.

As will be clear to one skilled in the art, a variety of sequences is available for preparation of the starting materials, and the sequences leading to the starting materials and products of the invention may be altered if appropriate considerations regarding the synthetic methods and radicals present are followed.

The utility of a compound of the invention or a pharmaceutically acceptable salt thereof (hereinafter, collectively referred to as a "Compound") may be demonstrated by standard tests and clinical studies, including those disclosed in the EPA publications noted above, such as EPA 428434 or EPA 474561, and those described below.

Neurokinin A (NKA) Receptor-binding Assay (Test A)

The ability of a Compound of the invention to antagonize the binding of NKA at the NK2 receptor may be demonstrated using an assay using the human NK2 receptor expressed in Mouse Erythroleukemia (MEL) cells, as described in: Aharony, D., Little, J., Thomas, C., Powell, S., Berry, D. and Graham, A. Isolation and Pharmacological Characterization of a Hampster Neurokinin A Receptor cDNA, Molecular

Pharmacology, 1994, 45, 9-19. In an initial use of this assay, the IC_{50} measured for the standard compound L-659,877 was found to be 30 nM versus ^{3}H-NKA binding to MELM.

The selectivity of a Compound for binding at the NK2 receptor may be shown by determining its binding at other receptors using standard assays, for example, one using a tritiated derivative of SP in a tissue preparation selective for NK1 receptors or one using a tritiated derivative of NKB in a tissue preparation selective for NK3 receptors.

Guinea Pig Assay (Test B)

The ability of a Compound of the invention to antagonize the action of an agonist, either NKA or [β-ala^{8}]-NKA(4-10), in a pulmonary tissue may be demonstrated using a functional assay in guinea pig trachea, which is carried out as follows. The chosen agonist is refered to as AG throughout the description.

Male guinea pigs are killed by a sharp blow to the back of the head. The trachea are removed, trimmed of excess tissue and divided into two segments. Each segment is suspended as a ring between stainless steel stirrups in water-jacketed (37.5 °C) tissue baths containing a physiological salt solution of the following composition (mM): NaCl, 119; KCl 4.6; $CaCl_2$, 1.8; $MgCl_2$, 0.5; NaH_2PO_4, 1; $NaHCO_3$, 25; glucose, 11; thiorphan, 0.001; and indomethacin, 0.005; gassed continuously with 95% O_2-%5 CO_2. Initial tension placed on each tissue is 1 g, which is maintained throughout a 0.5 to 1.5 hour equilibration period before addition of other drugs. Contractile responses are measured on a Grass polygraph via Grass FT-03 force transducers.

Tissues are challenged repetitively with a single concentration of AG (10 nM) with intervening 30 min periods with washing to allow the tension to return to baseline levels. The magnitude of the contractions to AG reaches a constant level after two challenges, and each Compound is tested for inhibition of responses to AG by addition to the tissue bath 15 minute before the third or subsequent exposure to the agonist. The contractile response to AG in

the presence of Compound is compared to that obtained with the second AG challenge (in the absence of Compound). Percent inhibition is determined when a Compound produces a statistically significant ($p<0.05$) reduction of the contraction and is calculated using the second contractile response as 100%.

Potencies of selected Compounds are evaluated by calculating apparent dissociation constants (K_B) for each concentration tested using the standard equation:

$$K_B=[\text{antagonist}]/(\text{dose ratio}-1)$$

where dose ratio = antilog[(AG -log molar EC_{50} without Compound) - (AG -log molar EC_{50} with Compound)]. The K_B values may be converted to the negative logarithms and expressed as -log molar K_B (i.e. pK_B). For this evaluation, complete concentration-response curves for AG are obtained in the absence and presence of Compound (30 min incubation period) using paired tracheal rings. The potency of AG is determined at 50% of its own maximum response level in each curve. The EC_{50} values are converted to the negative logarithms and expressed as -log molar EC_{50}. Maximum contractile responses to AG are determined by expressing the maximum response to AG as a percentage of the contraction caused by carbachol (30μM), added after the initial equilibration period. When a statistically significant ($p<0.05$) reduction of the maximum response to AG is produced by a compound, the percent inhibition is calculated relative to the percentage of carbachol contraction in the untreated, paired tissue used as 100%.

Clinical studies to demonstrate the efficacy of a Compound of the invention may be carried out using standard methods. For example, the ability of a Compound to prevent or treat the symptoms of asthma or asthma-like conditions may be demonstrated using a challenge of inhaled cold air or allergen and evaluation by standard pulmonary measurements such as, for example, FEV_1 (forced expiratory volume in one second) and FVC (forced vital capacity), analyzed by standard methods of statistical analysis.

It will be appreciated that the implications of a Compound's activity in Test A or Test B is not limited to asthma, but rather,

that the test provides evidence of general antagonism of NKA. In general, the Compounds of the invention which were tested demonstrated statistically significant activity in Test A with a K_i of 1 μM or much less. In Test B, a pK_B of 5 or greater was typically measured for a Compound of the invention. It should be noted that there may not always be a direct correlation between the activities of Compounds measured as K_i values in Test A and the values measured in other assays, such as the pK_B measured in Test B.

As discussed above, a compound of formula I or a pharmaceutically acceptable salt thereof possesses NKA antagonist properties. Accordingly, it antagonizes at least one of the actions of NKA which are known to include bronchoconstriction, increased microvascular permeability, vasodilation and activation of mast cells. NKA antagonists have also been reported to be useful for the treatment of diseases including arthritis, inflamation pain, gastrointestinal-hypermotility, Huntington's Disease, Psycoses, hypertension, migrane and uticaria (U.S.Patent 5,236,921). Accordingly, one feature of the invention is the use of a compound of formula I or a pharmaceutically acceptable salt thereof in the treatment of a disease in a human or other mammal in need thereof in which NKA is implicated and antagonism of its action is desired, such as for example the treatment of asthma or a related disorder. In addition, another feature of the invention is provided by the use of a compound of formula I or a salt thereof as a pharmacological standard for the development and standardization of new disease models or assays for use in developing new therapeutic agents for treating the diseases in which NKA is implicated or for assays for their diagnosis.

When used in the treatment of such a disease, a compound of the invention is generally administered as an appropriate pharmaceutical composition which comprises a compound of formula I or a pharmaceutically acceptable salt thereof as defined hereinbefore and a pharmaceutically acceptable diluent or carrier, the composition being adapted for the particular route of administration chosen. Such a composition is provided as a further feature of the invention. It may be obtained employing conventional procedures and excipients and binders, and it may be one of a variety of dosage forms. Such forms

include, for example, tablets, capsules, solutions or suspensions for oral adminisòation; suppositories for rectal administration; sterile solutions or suspensions for administration by intravenous or intramuscular infusion or injection; aerosols or nebulizer solutions or suspensions for administration by inhalation; or powders together with pharmaceutically acceptable solid diluents such as lactose for administration by insufflation.

For oral administration a tablet or capsule containing up to 250 mg (and typically 5 to 100 mg) of a compound of formula I may conveniently be used. For administration by inhalation, a compound of formula I will be administered to humans in a daily dose range of, for example, 5 to 100 mg, in a single dose or divided into two to four daily doses. Similarly, for intravenous or intramuscular injection or infusion a sterile solution or suspension containing up to 10% w/w (and typically 0.05 to 5% w/w) of a compound of formula I may conveniently be used.

The dose of a compound of formula I to be administered will necessarily be varied according to principles well known in the art taking account of the route of administration and the severity of the condition and the size and age of the patient under treatment. However, in general, the compound of formula I will be administered to a warm-blooded animal (such as man) so that a dose in the range of, for example, 0.01 to 25 mg/kg (and usually 0.1 to 5 mg/kg) is received. It will be understood that generally equivalent amounts of a pharmaceutically acceptable salt of a compound of formula I may be used.

The invention will now be illustrated by the following non-limiting examples in which, unless stated otherwise:

(i) temperatures are given in degrees Celsius (°C); operations were carried out at room or ambient temperature, that is, at a temperature in the range of 18-25 °C;

(ii) organic solutions were dried over anhydrous sodium sulfate; evaporation of solvent was carried out using a rotary evaporator under reduced pressure (600-4000 pascals; 4.5-30 mm Hg) with a bath temperature of up to 60 °C;

(iii) chromatography means 'flash chromatography' (method of

Still) carried out on Merck Kieselgel (Art 9385 from E. Merck, Darmstadt, Germany); reversed phase silica gel means octadecylsilane (ODS) coated support having a particle diameter of 32-74 μ, known as "PREP-40-ODS" (Art 731740-100 from Bodman Chemicals, Aston, PA, USA); thin layer chomatography (TLC) was carried out on 0.25 mm silica gel GHLF plates (Art 21521 from Analtech, Newark, DE, USA);

(iv) in general, the course of reactions was followed by TLC and reaction times are given for illustration only;

(v) melting points are uncorrected and (d) indicates decomposition; the melting points given are those obtained for the materials prepared as described; polymorphism may result in isolation of materials with different melting points in some preparations;

(vi) final products had satisfactory nuclear magnetic resonance (NMR) spectra and were substantially pure by TLC;

(vii) yields are given for illustration only and are not necessarily those which may be obtained by diligent process development; preparations were repeated if more material was required;

(viii) when given, NMR data is in the form of delta values for major diagnostic protons, given in parts per million (ppm) relative to tetramethylsilane (TMS) as an internal standard, determined at 300 MHz using $CDCl_3$ as solvent; conventional abbreviations for signal shape are used; for AB spectra the directly observed shifts are reported; "DMSO-d_6" means perdeuterio dimethyl sulfoxide;

(ix) chemical symbols have their usual meanings; SI units and symbols are used;

(x) reduced pressures are given as absolute pressures in pascals (Pa); elevated pressures are given as gauge pressures in bars;

(xi) solvent ratios are given in volume: volume (v/v) terms; and

(xii) mass spectra (MS) were run with an electron energy of 70 electron volts in the chemical ionizaton mode using a direct exposure probe; generally, only peaks which indicate the parent mass are reported.

EXAMPLE 1: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-ethoxycarbonyl-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide hydrochloride.

(S)-N-[2-(3,4-Dichlorophenyl)-4-oxobutyl]-N-methylbenzamide (415 mg) in methanol (3 mL) was added to a solution of 4-ethoxycarbonyl-4-(2-oxopiperidino)piperidine (391 mg) and acetic acid (0.09 mL) in methanol (6 mL). After 15 minutes, sodium cyanoborohydride (100 mg) in methanol (3 mL) was added in a single portion. After being stirred for 3 hours, the reaction mixture was diluted with aqueous sodium bicarbonate, stirred for 30 minutes, and extracted with dichloromethane. The organic extracts were dried, evaporated, and chromatographed, with dichloromethane:methanol (95:5) as eluent. The resulting material was dissolved in dichloromethane, precipitated out as the hydrochloride salt with ethereal hydrogen chloride, evaporated, and placed under high vacuum overnight to give the title compound as a white solid (630 mg); MS: m/z=588(M+1). Analysis for $C_{31}H_{39}Cl_2N_3O_4 \cdot 1.70\ HCl \cdot 0.20\ (C_2H_5)_2O$: Calculated: C, 57.40; H, 6.46; N, 6.31; Found: C, 57.40; H, 6.37; N, 6.17.

The (S)-N-[2-(3,4-dichlorophenyl)-4-oxobutyl]-N-methylbenzamide was prepared as follows:

a. 1-Bromo-2-(tetrahydropyran-2-yloxy)ethane. To a mechanically stirred solution of dihydropyran (1 L) and a strong acid ion exchange resin (10.0 g) in hexane (2 L) was added 2-bromoethanol (985 g) dropwise over a period of 1.5 hours. Throughout the addition, a cold water bath was used to maintain an internal temperature of 35-40 °C. After being stirred overnight at room temperature, the reaction mixture was chromatographed, eluting with hexane (6 L). The eluent was evaporated to give an amber liquid which was distilled through a 2 inch vigreux column. The material boiling between 75-95 °C (3,300-4,700 Pa) was collected and redistilled to give the ether (1195.5 g) as an oil; bp 80-90 °C (2666 Pa); NMR: 4.68 (m,1), 4.01 (m,1), 3.89 (m,1), 3.77 (m,1), 3.52 (m,3), 1.75-1.50 (m,6).

b. 2-(3,4-Dichlorophenyl)-4-(tetrahydropyran-2-yloxy)-butyronitrile. To a solution of sodium hydride (218.0 g of a 55% oil suspension) in tetrahydrofuran (4 L) at 10 °C in an ice/water bath was added 3,4-dichlorophenylacetonitrile (893.0 g) in tetrahydrofuran (2 L) over a period of 45 minutes. The resulting solution was allowed to stir for 2 hours at room temperature. The mixture was cooled in an ice/water bath and 1-bromo-2-(tetrahydropyran-2-yloxy)ethane (1076.0 g) was dropped in as a neat oil over a period of 25 minutes. The mixture was stirred overnight at room temperature and divided into four 2-liter portions. Each portion was diluted with saturated ammonium chloride (3 L) and extracted with ether (500 mL). The combined organic layers were washed (aqueous ammonium chloride), dried, and evaporated. The resulting material was chromatographed, with hexane:dichloromethane (gradient 100:0, 0:100) as the eluent, to give the nitrile (932 g) as an oil; NMR: 7.47 (m,4), 7.20 (m,2), 4.57 (m,2), 4.08 (m,2), 3.85 (m,4), 3.54 (m,3), 3.37 (m,1), 2.15 (m,4), 1.77 (m,4), 1.56 (m,8).

c. 2-(3,4-Dichlorophenyl)-4-(tetrahydropyran-2-yloxy)butyl-amine. To a solution of the above nitrile (128.3 g) in 95% ethanol (1.1 L) and concentrated ammonium hydroxide (550 mL) was added Raney Nickel (25.0 g). The mixture was placed under a hydrogen atmosphere (3.6 bar) for 1.5 days. The mixture was filtered through diatomaceous earth to remove the catalyst, and the resulting filtrate was evaporated. The resulting material was chromatographed, with dichloromethane:methanol (gradient 100:0, 95:5) as the eluent, to give the amine (91 g) as an oil; NMR: 7.40 (s,1), 7.38 (s,1), 7.32 (d,1, J=2.1), 7.28 (d,1, J=2.0), 7.07 (dd,1, J=2.1, 4.9), 7.04 (dd,1, J=2.1, 4.9), 4.50 (m,1), 4.43 (m,1), 3.70 (m,4), 3.45 (m,2), 3.27 (m,1), 3.17 (m,1), 2.97-2.75 (m,6), 2.00 (m,2), 1.82-1.66 (m,6), 1.53 (m,8), 1.18 (broad s,4); MS: m/z=318(M+1), 234[(M+1)-tetrahydropyranyl].

d. 2-(3,4-Dichlorophenyl)-4-hydroxybutylamine. To a mechanically stirred solution of 2-(3,4-dichlorophenyl)-4-(tetrahydropyran-2-yloxy)butylamine (550 g) in methanol (3.3 L) was added in one portion 6.0 N hydrochloric acid (352 mL), resulting in a

slight exotherm. After being stirred for 3 hours, the reaction mixture was evaporated, and the residue was diluted with water to 3 L volume. This solution was extracted with ether (2 times 500 mL), basified with sodium hydroxide pellets (100 g), and extracted with ethyl acetate (4 times 500 mL). The combined ethyl acetate extracts were washed (800 mL saturated sodium chloride), dried, and evaporated to give the alcohol as an amber oil (367 g) that solidified under high vacuum; NMR: 7.39 (d,1, J=8.2), 7.28 (d,1, J=2.0), 7.04 (dd,1, J=8.2, 2.0), 3.65 (m,1), 3.50 (m,1), 2.90 (m,2), 2.71 (m,1), 2.25 (m,2), 1.86 (m,2).

e. (S)-2-(3,4-Dichlorophenyl)-4-hydroxybutylamine. To a mechanically stirred solution of D-tartaric acid (222 g) in methanol (4 L) at reflux was added the above alcohol (342 g) in warm methanol (2 L) in one portion followed by additional methanol (1 L). The mixture was heated to reflux. Crystals began to form before attaining the boiling point. After 1.5 hours at reflux, the solution was gradually cooled to room temperature and stirred for 3 days. The first crop of tartrate salt was collected by suction filtration and dried in a vacuum oven at 60 °C to give the product (232 g). This material was taken up in methanol (13.5 L) at boiling, and held at reflux for 1 hour allowing 1 L of methanol to distill off. The mixture was allowed to cool gradually to room temperature and stirred for 4 days. The first crop of crystals was collected by suction filtration and dried to give a solid (178.8 g). The methanol filtrate was evaporated to approximately 3 L volume. The resulting suspension was heated back to reflux to give a clear solution that was allowed to cool gradually to room temperature with stirring. A second crop of crystals (43.8 g) was collected. The combined crops of resolved amino alcohol tartrates (222.6 g) were taken up in 1.0 N sodium hydroxide (1.5 L) and extracted with dichloromethane (4 times 500 mL). The combined organic extracts were washed (brine), dried, and evaporated to give the optically enriched alcohol (135.4 g) as an off-white solid; mp 80-2 °C; MS: m/z=324(M+1); NMR (CD_3OD): 7.47 (d,1, J=8.3), 7.42 (d,1, J=2.1), 7.17 (dd,1, J=8.2, 2.1), 3.47 (m,1), 3.34 (m,1), 2.83 (m,3), 1.92 (m,1), 1.74 (m,1).

f. Ethyl (S)-N-[2-(3,4-dichlorophenyl)-4-hydroxybutyl]-carbamate. Ethyl chloroformate (25.5 g) was added dropwise over 20 minutes to a mechanically stirred solution of the above alcohol (50.0 g) and triethylamine (24.9 g) in dichloromethane (600 mL). The internal temperature was maintained at -20 to -25 °C during the addition. The reaction mixture was allowed to warm gradually to room temperature over a 4 hour period, and was washed (1 N hydrochloric acid, saturated aqueous sodium bicarbonate, and saturated aqueous sodium chloride). The separated dichloromethane phase was dried and evaporated to give the carbamate as a yellow oil (65.3 g); MS: m/z=306(M+1); NMR (CD_3OD): 7.44 (d,1, J=8.3), 7.38 (d,1, J=2.1), 7.15 (dd,1, J=8.3, 2.1), 3.99 (q,2, J=7.1), 3.45 (m,1), 3.29 (m,3), 2.97 (m,1), 1.92 (m,1), 1.75 (m,1), 1.16 (t,3, J=7.1).

g. (S)-N-[2-(3,4-Dichlorophenyl)-4-hydroxybutyl]methylamine. The above carbamate (65.3 g) in tetrahydrofuran (500 mL) was added dropwise over 30 minutes to a mechanically stirred supension of lithium aluminum hydride (16.0 g) in tetrahydrofuran (200 mL). The internal temperature rose to 45 °C during the addition. The reaction mixture was heated at reflux for 1 hour, cooled to room temperature and stirred overnight. The mixture was cooled in an ice bath, and saturated aqueous sodium sulfate (50 mL) was added dropwise over 45 minutes. After an additional hour of stirring, solid anhydrous sodium sulfate (50 g) was added. After being stirred for 30 minutes, the mixture was filtered through diatomaceous earth, and the filtrate was evaporated to give the amine (52.9 g) as a yellow oil; MS: m/z=248(M+1); NMR: 7.37 (d,1, J=8.2), 7.27 (d,1, J=2.0), 7.01 (dd,1, J=8.2, 2.1), 3.69 (m,1), 3.53 (m,1), 3.40 (m,2), 2.76 (m,3), 2.45 (m,3), 1.89 (m,2).

h. (S)-N-[2-(3,4-Dichlorophenyl)-4-hydroxybutyl]-N-methylbenzamide. Benzoyl chloride (31.5 g) in dichloromethane (200 mL) was added dropwise over 45 minutes to a mechanically stirred solution of the above amine (52.9 g) and triethylamine (54.0 g) in dichloromethane (1 L). An ice bath was used throughout the addition to maintain an

internal temperature of 5-8 °C. The reaction mixture was stirred for 3 hours at room temperature, and washed (1 N hydrochloric acid, brine). The separated dichloromethane layer was evaporated to give a yellow oil which was chromatographed, with dichloromethane:methanol (gradient 100:0, 95:5) as the eluent, to give the benzamide (65.6 g) as a white solid; mp 123-5 °C; MS: m/z=352(M+1); $[\alpha]_D$=-18.3° (c=2.46, CH_3OH).

i. (S)-N-[2-(3,4-Dichlorophenyl)-4-oxobutyl]-N-methylbenzamide. The above benzamide (12.9 g) in dichloromethane (150 mL) was cannulated into a solution of 1,1,1-triacetoxy-1,1-dihydro-1,2-benziodoxol-3-(1H)-one (18.6 g) and tert-butanol (4.5 mL) in dichloromethane (150 mL). After being stirred for 5 minutes, the reaction mixture was diluted with ether (600 mL) and a solution of sodium bicarbonate (19.7 g) and sodium thiosulfate pentahydrate (64.5 g) in water (825 mL). The biphasic system was vigorously stirred until both layers became clear (approximately 30 minutes). The separated organic layer was washed (saturated aqueous sodium bicarbonate), dried, and evaporated. The crude material was chromatographed, with dichloromethane:ether (1:1) as the eluent, to give the aldehyde as a white solid (9.7 g) following precipitation and filtration from ether; MS: m/z=350(M+1).

The intermediate piperidine was prepared as follows:

j. 8-Benzyl-1,3,8-triazaspiro[4.5]decane-2,4-dione. 1-Benzyl-4-piperidone (100 g) was added in a single portion to a mechanically stirred suspension of ammonium carbonate (488.5 g) and sodium cyanide (70.0 g) in water (700 mL) and ethanol (700 mL). The reaction mixture was stirred at 60 °C for 12 hours. The inorganic salts dissolve gradually in the solution and spirohydantoin crystals formed. Upon cooling to room temperature, the solids were collected by filtration, washed with warm water (2 L), recrystallized from 80% ethanol (2 L), washed with ethanol, and dried in a vacuum oven at 50 °C to give the hydantoin (122 g) as a white solid; MS: m/z=260(M+1); NMR (DMSO-d_6): 10.64 (bs,1), 8.45 (broad s,1),

7.29 (m,5), 3.48 (s,2), 2.69 (m,2), 2.28 (m,2), 1.81 (m,2), 1.51 (m,2).

k. 4-Amino-1-benzyl-4-carboxypiperidine. A stirred solution of the hydantoin (40.0 g) and lithium hydroxide monohydrate (32.4 g) in water (500 mL) was heated at reflux for 40 hours. The mixture was cooled to room temperature, filtered to remove the white precipitate, and the filtrate evaporated. The pH of the concentrate was adjusted from 12 to 5 with concentrated hydrochloric acid and the solution was evaporated to dryness. The residue was suspended in methanol to provide a white precipitate that was filtered, washed with methanol, and air-dried to give the amine (32.7 g) as a white solid; MS: m/z=235(M+1); NMR (DMSO-d_6): 7.40 (m,5), 3.89 (m,2), 2.92 (m,4), 2.12 (m,2), 1.84 (m,2).

l. 4-Amino-1-benzyl-4-ethoxycarbonylpiperidine. Thionyl chloride (43.0 mL) was added dropwise to a suspension of the amino-acid (23.0 g) in ethanol (400 mL) at 0 °C to give a clear solution. The reaction mixture was warmed to room temperature, refluxed for 5 hours, and stirred overnight at room temperature. The mixture was evaporated and stripped twice from toluene. The resulting oil was dissolved in water, adjusted to pH 3 with 1 N sodium hydroxide, neutralized with saturated aqueous sodium bicarbonate, and extracted with dichloromethane. The organic extracts were dried and evaporated to give the ester (21.5 g) as an oil; MS: m/z=263(M+1); NMR: 7.28 (m,5), 4.17 (q,2, J=7.1), 3.52 (s,2), 2.50 (m,4), 2.13 (m,2), 1.54 (m,4), 1.27 (t,3, J=7.1).

m. 1-Benzyl-4-(5-chlorovaleramido)-4-ethoxycarbonylpiperidine. 5-Chlorovaleryl chloride (13.2 g) in dichloromethane (50 mL) was added dropwise to a solution of the above amino-ester (20.3 g) and pyridine (13.1 mL) in dichloromethane (250 mL) at 0 °C, resulting in the formation of a thick slurry within 20 minutes. After being warmed to room temperature overnight, the slurry was diluted with aqueous sodium bicarbonate to give a clear, biphasic solution, which was further extracted with dichloromethane. The organic extracts were dried and

evaporated to a light brown semi-solid. The material was suspended in ether and filtered to give the amide (16.8 g) as a white solid; MS: m/z=381(M+1); NMR (CD_3OD): 7.28 (m,5), 4.11 (q,2, J=7.1), 3.55 (m,4), 2.68 (m,2), 2.26 (m,4), 2.05 (m,4), 1.75 (m,4), 1.21 (t,3, J=7.1).

n. 1-Benzyl-4-ethoxycarbonyl-4-(2-oxopiperidino)piperidine. A solution of the above amide (16.8 g) in tetrahydrofuran (50 mL) was cannulated into a suspension of sodium hydride (2.1 g) in tetrahydrofuran (150 mL). After being stirred overnight, the reaction mixture was quenched with water, concentrated (to remove tetrahydrofuran), diluted with water, and extracted with dichloromethane. The combined organic extracts were dried and evaporated. The crude product was chromatographed, with dichloromethane:methanol (gradient 97:3, 95:5) as eluent, to give 1-benzyl-4-ethoxycarbonyl-4-(2-oxopiperidino)piperidine (13.2 g) as a solid; MS: m/z=345(M+1); NMR (CD_3OD): 7.30 (m,5), 4.11 (q,2, J=7.1), 3.54 (s,2), 3.44 (m,2), 2.66 (m,2), 2.52 (m,2), 2.32 (m,2), 2.20 (m,2), 2.01 (m,2), 1.85 (m,2), 1.74 (m,2), 1.20 (t,3, J=7.1).

o. 4-Ethoxycarbonyl-4-(2-oxopiperidino)piperidine. A solution of 1-benzyl-4-ethoxycarbonyl-4-(2-oxopiperidino)piperidine (12.4 g) and 20% palladium hydroxide on carbon (2.0 g) in ethanol (150 mL) was stirred overnight under hydrogen (1 bar). The reaction mixture was filtered through diatomaceous earth, and the filtrate was evaporated to give 4-ethoxycarbonyl-4-(2-oxopiperidino)piperidine (9.1 g) as a viscous oil; MS: m/z=255(M+1); NMR (CD_3OD): 4.13 (q,2, J=7.1), 3.44 (m,2), 2.95 (m,4), 2.32 (m,2), 2.19 (m,2), 1.88 (m,4), 1.74 (m,2), 1.23 (t,3, J=7.1).

EXAMPLE 2: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)piperidino]butyl]-N-methylbenzamide citric acid salt.

(S)-N-[2-(3,4-Dichlorophenyl)-4-oxobutyl]-N-methylbenzamide (350 mg) in methanol (3 mL) was added to a solution of

4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)piperidine (330 mg) and acetic acid (0.07 mL) in methanol (5 mL). After 10 minutes, sodium cyanoborohydride (100 mg) in methanol (2 mL) was added in a single portion. After being stirred for 3 hours, the reaction mixture was diluted with aqueous sodium bicarbonate, stirred for 30 minutes, and extracted with dichloromethane. The organic extracts were dried, evaporated, and chromatographed, with dichloromethane:methanol (95:5) as eluent. The resulting material (410 mg) was dissolved in methanol containing 1 equivalent of citric acid (128 mg), evaporated, suspended and pulverized in ether, evaporated, and placed under high vacuum to give the title compound as a white solid (540 mg); MS: m/z=613(M+1), 542[(M+1)-pyrrolidine]. Analysis for $C_{33}H_{42}Cl_2N_4O_3 \cdot 1.40\ H_2O \cdot 0.65\ (C_2H_5)_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 56.83; H, 6.80; N, 6.37; Found: C, 56.89; H, 6.74; N, 6.27.

The intermediate piperidine was prepared as follows:

a. 1-Benzyloxycarbonyl-4-(ethoxycarbonyl)-4-(2-oxopiperidino)-piperidine. 4-(Ethoxycarbonyl)-4-(2-oxopiperidino)piperidine (9.0 g) in dichloromethane (25 mL) was added to a solution of N-(benzyloxy-carbonyloxy)succinimide (8.8 g) and triethylamine (5.4 mL) in dichloromethane (150 mL). After 1.5 hours, the reaction mixture was washed successively with 1.0 N hydrochloric acid and saturated aqueous sodium bicarbonate. The separated organic layer was dried and evaporated to give the title compund (11.6 g) as a light yellow solid; MS: m/z=389(M+1); NMR ($CDCl_3/CF_3COOH$): 7.37 (m,5), 5.16 (s,2), 4.28 (q,2, J=7.1), 4.09 (m,2), 3.40 (m,2), 3.28 (m,2), 2.53 (m,2), 2.34 (m,2), 1.83 (m,6), 1.30 (t,3, J=7.1).

b. 1-Benzyloxycarbonyl-4-carboxy-4-(2-oxopiperidino)piperidine. A solution of 1-benzyloxycarbonyl-4-ethoxycarbonyl-4-(2-oxo-piperidino)piperidine (11.4 g) in tetrahydrofuran (150 mL), 1.0 N sodium hydroxide (50 mL), and methanol (volume necessary to obtain clear solution) was heated at reflux for 10 hours. The reaction mixture was evaporated and the resulting aqueous solution was diluted with water and extracted with dichloromethane to recover unreacted

starting material (3.7 g). The aqueous phase was acidified to pH 3 with 1.0 N hydrochloric acid and extracted with dichloromethane. The combined organic extracts were washed with water, dried, and evaporated to furnish a light yellow solid. The material was suspended in ether and filtered to give the title compound (6.3 g) as a white solid; MS: m/z=361(M+1); NMR ($CDCl_3$/CF_3COOH): 7.37 (m,5), 5.17 (s,2), 4.11 (m,2), 3.45-3.32 (m,4), 2.55 (m,2), 2.37 (m,2), 1.94-1.78 (m,6).

c. 1-Benzyloxycarbonyl-4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)piperidine. A solution of 1-benzyloxycarbonyl-4-carboxy-4-(2-oxopiperidino)piperidine (300 mg), pyrrolidine (0.083 mL), 4-(dimethylamino)pyridine (122 mg), and 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (192 mg) in dichloromethane (5 mL) was stirred for 3.5 hours. The reaction mixture was diluted with dichloromethane and washed successively with 1.0 N hydrochloric acid, saturated aqueous sodium bicarbonate, and water. The separated organic layer was dried and evaporated to give the title compound (260 mg) as a white solid which was used directly in the next step without further purification; MS: m/z=343[(M+1)-pyrrolidine]; NMR (CD_3OD): 7.33 (m,5), 5.10 (s,2), 3.98 (m,2), 3.45-3.20 (m,8), 2.36 (m,2), 2.26 (m,2), 1.92-1.68 (m,10).

d. 4-(2-Oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)piperidine. A solution of 1-benzyloxycarbonyl-4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)piperidine (660 mg) and 20% palladium hydroxide on carbon (150 mg) in ethanol (8 mL) was stirred overnight under hydrogen (1 bar). The reaction mixture was filtered through diatomaceous earth, and the filtrate was evaporated to give 4-(2-oxopiperidino)-4-(1-pyrrolidinylcarbonyl)piperidine (430 mg) as an off-white solid; MS: m/z=280(M+1), 209[(M+1)-pyrrolidine]; NMR (CD_3OD): 3.44 (m,4), 3.26-3.11 (m,4), 2.98 (m,2), 2.37 (m,2), 2.28 (m,2), 1.92-1.69 (m,10).

The intermediate 1-Benzyloxycarbonyl-4-carboxy-4-(2-oxopiperidino)piperidine described in sub-part b. above, can alternatively be prepared as follows.

1-Benzyloxycarbonyl-4-carboxy-4-(2-oxopiperidino)piperidine. A solution of 4-(ethoxycarbonyl)-4-(2-oxopiperidino)piperidine (15.85 g) in tetrahydrofuran (125 mL), 1.0 N sodium hydroxide (125 mL), and water (235 mL) was refluxed for 6 hours. The reaction mixture was diluted with 1.0 N hydrochloric acid (65 mL) and concentrated to dryness in vacuo. The residue was taken up in ethanol, and the undissolved salts were filtered off. The filtrate was evaporated, and the resulting material was dissolved in dichloromethane (500 mL). Triethylamine (17.4 mL) and N-(benzyloxycarbonyloxy)succinimide (17.0 g) were added to the turbid solution. After being stirred overnight, the reaction mixture was extracted with 1.0 N sodium hydroxide (250 mL). The separated dichloromethane layer was washed (0.1 N hydrochloric acid, aqueous sodium bicarbonate), dried, and evaporated to yield recovered 1-benzyloxycarbonyl-4-(ethoxycarbonyl)-4-(2-oxopiperidino)piperidine (12.0 g). The basic aqueous layer was adjusted to pH 1 with concentrated hydrochloric acid, and extracted with dichloromethane. The organic extracts were clarified with methanol, dried, and evaporated to give the acid as a white solid (15.8 g).

EXAMPLE 3: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-methoxycarbonyl-4-(2-oxoperhydropyrimidin-1-yl)piperidino]butyl]-N-methylbenzamide citric acid salt.

Using a procedure similar to that described in Example 2, except replacing 4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)-piperidine with 4-methoxycarbonyl-4-(2-oxoperhydropyrimidin-1-yl)-piperidine, the title compound was obtained as a white solid; MS: m/z=575(M+1). Analysis for $C_{29}H_{36}Cl_2N_4O_4 \cdot 1.95\ CH_3OH \cdot 1.0\ C_6H_8O_7$: Calculated: C, 53.46; H, 6.29; N, 6.74; Found: C, 53.49; H, 6.01; N, 6.35.

The intermediate piperidine was prepared as follows:

a. 1-Benzyl-4-[N'-(3-chloropropyl)ureido]-4-ethoxycarbonylpiperidine. 3-Chloropropyl isocyanate in dichloromethane (20 mL) was added to a solution of 4-amino-1-benzyl-4-ethoxycarbonylpiperidine (3.1 g) in dichloromethane (40 mL) at 0 °C. After 10 minutes, the reaction mixture was evaporated, dissolved in ether to produce a precipitate, and filtered to give the title compound (3.5 g) as a white solid; NMR (CD_3OD): 7.31 (m,5), 4.12 (q,2, J=7.1), 3.58 (t,2, J=6.6), 3.53 (s,2), 3.21 (t,2, J=6.6), 2.69 (m,2), 2.32 (m,2), 2.11-1.85 (m,6), 1.22 (t,3, J=7.1).

b. 1-Benzyloxycarbonyl-4-[N'-(3-chloropropyl)ureido]-4-ethoxycarbonylpiperidine. 1-Chloroethyl chloroformate (2.83 mL) was added dropwise to a solution of 1-benzyl-4-[N'-(3-chloropropyl)-ureido]-4-ethoxycarbonylpiperidine (10 g) in 1,2-dichloroethane at 0 °C. After 15 minutes, the reaction mixture was refluxed for 1 hour, evaporated, dissolved in methanol (200 mL), refluxed for 30 minutes, diluted with toluene, and evaporated. The crude residue was dissolved in dichloromethane (200 mL) followed by the addition of N-(benzyloxycarbonyloxy)succinimide (6.53 g) and triethylamine (7.3 mL). After 30 minutes, the reaction mixture was diluted with dichloromethane, and washed successively with 1.0 N hydrochloric acid and dilute aqueous sodium bicarbonate. The separated organic phase was dried, evaporated, and purified by chromatography, with dichloromethane:ether (gradient 5:1, 1:1) as eluent, to give the title compound as a foamy, white solid (7.8 g); MS: m/z=426(M+1); NMR: 7.35 (m,5), 5.13 (s,2), 4.87 (m,2), 4.18 (q,2, J=7.1), 3.88 (m,2), 3.59 (m,2), 3.27 (m,4), 1.99 (m,6), 1.25 (t,3, J=7.1).

c. 1-Benzyloxycarbonyl-4-carboxy-4-[N'-(3-chloropropyl)ureido]-piperidine. A solution of 1-benzyloxycarbonyl-4-[N'-(3-chloropropyl)-ureido]-4-ethoxycarbonylpiperidine (7.6 g) in tetrahydrofuran (108 mL), methanol (35 mL), and 1.0 N sodium hydroxide (36 mL) was stirred overnight. The reaction mixture was concentrated in vacuo, and the resulting basic aqueous solution was diluted with water and

extracted with dichloromethane. The organic extracts were dried and evaporated to recover unreacted starting material (2.8 g). The aqueous layer was acidified with 1.0 N hydrochloric acid, and extracted with dichloromethane. The organic extracts were dried and evaporated to give the title compound as foamy white solid (4.1 g); MS: m/z=380[(M+1-H_2O)]; NMR: 7.34 (m,5), 5.94 (m,2), 5.11 (m,2), 3.85 (m,2), 3.54 (m,2), 3.26 (m,4), 1.96 (m,6).

d. 1-Benzyloxycarbonyl-4-carboxy-4-(2-oxoperhydropyrimidin-1-yl)piperidine. Potassium tert-butoxide (25 mL, 1.0 M in tert-butanol) was added to a solution of 1-benzyloxycarbonyl-4-carboxy-4-[N'-(3-chloropropyl)ureido]piperidine (3.9 g) in tetrahydrofuran (25 mL). After being stirred for 2 hours, the reaction mixture was evaporated, dissolved in water, and extracted with dichloromethane (discarded). The aqueous layer was acidified with 1.0 N hydrochloric acid and extracted with dichloromethane. The organic extracts were dried and evaporated to a foamy solid which was suspended in ether and filtered to give the title compound as a white solid (3.2 g); MS: m/z=362(M+1); NMR: 7.35 (m,5), 6.58 (m,1), 5.12 (s,2), 3.70 (m,2), 3.53 (m,2), 3.34 (m,2), 3.26 (m,2), 2.27 (m,2), 1.95 (m,4).

e. 1-Benzyloxycarbonyl-4-methoxycarbonyl-4-(2-oxoperhydropyrimidin-1-yl)piperidine. The product from part d. was dissolved in methanol (20 mL) followed by the addition of a 2.0 M solution of (trimethylsilyl)diazomethane in hexanes (8 mL). After 10 minutes, the reaction mixture was evaporated to give the methyl ester (490 mg) as a white foamy solid; NMR ($CDCl_3$/CF_3COOH): 7.37 (m,5), 5.17 (s,2), 4.00 (m,2), 3.83 (s,3), 3.46 (m,2), 3.35 (m,4), 2.34 (m,2), 2.06 (m,2), 1.95 (m,2).

f. 4-Methoxycarbonyl-4-(2-oxoperhydropyrimidin-1-yl)piperidine. A solution of 1-benzyloxycarbonyl-4-methoxycarbonyl-4-(2-oxoperhydropyrimidin-1-yl)piperidine (490 mg) and 20% palladium hydroxide on carbon (40 mg) in ethanol (10 mL) was stirred overnight under hydrogen (1 bar). The reaction mixture was filtered through diatomaceous

earth, and the filtrate was evaporated to give 4-methoxycarbonyl-4-(2-oxoperhydropyrimidin-1-yl)piperidine (213 mg) as a white solid.

EXAMPLES 4-14

Using a procedure similar to that described in Example 2, except substituting the requisite piperidine for the 4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)piperidine used therein, the following compounds of formula I were prepared. Satisfactory NMR spectra were recorded for each compound.

EXAMPLE 4: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-(2-oxoperhydropyrimidin-1-yl)-4(pyrrolidin-1-ylcarbonyl)piperidino]butyl]-N-methylbenzamide citric acid salt; MS: m/z=614(M+1); Analysis for $C_{32}H_{41}Cl_2N_5O_3 \cdot 1.55\ H_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 54.68; H, 6.29; N, 8.39; Found: C, 54.68; H, 6.13; N, 8.32.

EXAMPLE 5: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-(methylaminocarbonyl)-4-(2-oxoperhydropyrimidin-1-yl)piperidino]butyl]-N-methylbenzamide citric acid salt; MS: m/z=574(M+1); Analysis for $C_{29}H_{37}Cl_2N_5O_3 \cdot 1.10\ H_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 53.45; H, 6.05; N, 8.90; Found: C, 53.44; H, 6.07; N, 8.55.

EXAMPLE 6: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-(methylaminocarbonyl)-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide citric acid salt; MS: m/z=573(M+1); Analysis for $C_{30}H_{38}Cl_2N_4O_3 \cdot 0.80\ H_2O \cdot 0.20\ (C_2H_5)_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 55.60; H, 6.29; N, 7.05; Found: C, 55.64; H, 6.28; N, 6.82.

EXAMPLE 7: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-(dimethylaminocarbonyl)-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide citric acid salt; MS: m/z=587(M+1); Analysis for $C_{31}H_{40}Cl_2N_4O_3 \cdot 1.0\ H_2O \cdot 0.20\ (C_2H_5)_2O \cdot 1.05\ C_6H_8O_7$: Calculated: C, 55.66; H, 6.42; N, 6.81; Found: C, 55.52; H, 6.36; N, 6.41.

EXAMPLE 8: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-(ethylaminocarbonyl)-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide citric acid salt; MS: m/z=587(M+1); Analysis for $C_{31}H_{40}Cl_2N_4O_3 \cdot 0.60\ H_2O \cdot 0.50\ (C_2H_5)_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 56.60; H, 6.60; N, 6.77; Found: C, 56.59; H, 6.54; N, 6.55.

EXAMPLE 9: (S)-N-[4-[4-(Benzylaminocarbonyl)-4-(2-oxopiperidino)-piperidino]-2-(3,4-dichlorophenyl)butyl]-N-methylbenzamide citric acid salt; MS: m/z=649(M+1); Analysis for $C_{36}H_{42}Cl_2N_4O_3 \cdot 0.30\ H_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 59.54; H, 6.02; N, 6.61; Found: C, 59.54; H, 6.24; N, 6.76.

EXAMPLE 10: (S)-N-[4-[4-[N-(Aminocarbonylmethyl)aminocarbonyl]-4-(2-oxopiperidino)piperidino]-2-(3,4-dichlorophenyl)butyl]-N-methylbenzamide citric acid salt; MS: m/z=616(M+1); Analysis for $C_{31}H_{39}Cl_2N_5O_4 \cdot 1.0\ H_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 53.75; H, 5.97; N, 8.47; Found: C, 53.78; H, 5.99; N, 8.13.

EXAMPLE 11: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-[N-(2-methoxycarbonyl-ethyl)aminocarbonyl]-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide citric acid salt; MS: m/z=645(M+1); Analysis for $C_{33}H_{42}Cl_2N_4O_5 \cdot 0.95\ H_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 54.79; H, 6.12; N, 6.55; Found: C, 54.79; H, 6.04; N, 6.57.

EXAMPLE 12: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-[N-(2-hydroxyethyl)-aminocarbonyl]-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide citric acid salt; MS: m/z=603(M+1); Analysis for $C_{31}H_{40}Cl_2N_4O_4 \cdot 0.85\ H_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 54.79; H, 6.17; N, 6.91; Found: C, 54.79; H, 6.23; N, 6.59.

EXAMPLE 13: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-[N-(2-hydroxyethyl)-N-methylaminocarbonyl]-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide citric acid salt; MS: m/z=617(M+1); Analysis for $C_{32}H_{42}Cl_2N_4O_4 \cdot 1.3\ H_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 54.78; H, 6.36; N, 6.72; Found: C, 54.71; H, 6.18; N, 6.82.

EXAMPLE 14: (S)-N-[4-[4-(Aminocarbonyl)-4-(2-oxopiperidino)-piperidino]-2-(3,4-dichlorophenyl)butyl]-N-methylbenzamide citric acid salt; MS: m/z=559(M+1); Analysis for $C_{29}H_{36}Cl_2N_4O_3 \cdot 1.35\ H_2O \cdot 1.05\ C_6H_8O_7$: Calculated: C, 53.97; H, 6.04; N, 7.13; Found: C, 53.99; H, 6.04; N, 6.84.

The starting material piperidines for Examples 4-14 were prepared as follows.

EXAMPLES 4.a.-14.a.

EXAMPLE 4.a.: 1-Benzyloxycarbonyl-4-(2-oxoperhydropyrimidin-1-yl)-4-(pyrrolidin-1-ylcarbonyl)piperidine. Using a procedure similar to that described in Example 2.c., except replacing 1-benzyloxycarbonyl-4-carboxy-4-(2-oxopiperidino)piperidine with 1-benzyloxycarbonyl-4-carboxy(2-oxoperhydropyrimidin-1-yl)piperidine, the amide was obtained as a white solid; NMR (CD_3OD): 7.35 (m,5), 5.11 (s,2), 3.96 (m,2), 3.38 (m,8), 3.17 (m,2), 2.28 (m,2), 1.91 (m,4), 1.79 (m,4).

EXAMPLEe 5.a.: 1-Benzyloxycarbonyl-4-(methylaminocarbonyl)-4-(2-oxoperhydropyrimidin-1-yl)piperidine. A solution of 1-benzyloxycarbonyl-4-carboxy-(2-oxoperhydropyrimidin-1-yl)piperidine (1.45 g), methylamine hydrochloride (0.32 g), 4-(dimethylamino)-pyridine (0.59 g), triethylamine (0.67 mL), and 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (0.92 g) in dichloromethane (20 mL) was stirred overnight. The reaction mixture was diluted with dichloromethane and washed successively with 1.0 N hydrochloric acid, saturated aqueous sodium bicarbonate, and water. The separated organic layer was dried and evaporated to give the title compound (1.37 g) as a white solid which did not require purification; NMR (CD_3OD): 7.35 (m,5), 5.11 (s,2), 3.71 (m,2), 3.36 (m,2), 3.19 (m,2), 2.69 (s,3), 2.14 (m,2), 1.96 (m,4).

EXAMPLE 6.a.: 1-Benzyloxycarbonyl-4-(methylaminocarbonyl)-4-(2-oxopiperidino)piperidine. Using a procedure similar to that described in Example 5.a., except replacing 1-benzyloxycarbonyl-4-carboxy-(2-oxoperhydropyrimidin-1-yl)piperidine with 1-benzyloxycarbonyl-4-

carboxy-4-(2-oxopiperidino)piperidine, the amide was obtained as a hygroscopic, white solid; NMR: 7.35 (m,5), 6.72 (m,1), 5.12 (s,2), 3.56 (m,4), 3.30 (m,2), 2.78 (d,3, J=4.8), 2.43 (m,2), 2.27 (m,2), 2.20 (m,2), 1.76 (m,4).

EXAMPLE 7.a.: 1-Benzyloxycarbonyl-4-(dimethylaminocarbonyl)-4-(2-oxopiperidino)piperidine. Using a procedure similar to that described in Example 5.a., except replacing 1-benzyloxycarbonyl-4-carboxy-(2-oxoperhydropyrimidin-1-yl)piperidine with 1-benzyloxycarbonyl-4-carboxy-4-(2-oxopiperidino)piperidine and methylamine hydrochloride with dimethylamine hydrochloride, the amide was obtained as a white solid; NMR: 7.35 (m,5), 5.12 (s,2), 4.03 (m,2), 3.57 (m,1), 3.26 (m,3), 2.91 (m,6), 2.42 (m,2), 2.33 (m,1), 2.18 (m,1), 1.86-1.69 (m,6).

EXAMPLE 8.a.: 1-Benzyloxycarbonyl-4-(ethylaminocarbonyl)-4-(2-oxopiperidino)piperidine. Using a procedure similar to that described in Example 5.a., except replacing 1-benzyloxycarbonyl-4-carboxy-(2-oxoperhydropyrimidin-1-yl)piperidine with 1-benzyloxycarbonyl-4-carboxy-4-(2-oxopiperidino)piperidine and methylamine hydrochloride with ethylamine hydrochloride, the amide was obtained as a white solid; NMR: 7.35 (m,5), 6.71 (m,1), 5.12 (s,2), 3.56 (m,4), 3.28 (m,4), 2.43 (m,2), 2.27 (m,2), 2.20 (m,2), 1.76 (m,4), 1.11 (t,3, J=7.2).

EXAMPLE 9.a.: 4-(Benzylaminocarbonyl)-1-benzyloxycarbonyl-4-(2-oxopiperidino)piperidine. Using a procedure similar to that described in Example 2.c., except replacing pyrrolidine with benzylamine, and purifying by suspending the crude product in ether and filtering, the amide was prepared as a white solid; NMR: 7.30 (m,10), 7.07 (m,1), 5.12 (s,2), 4.42 (d,2, J=5.8), 3.58 (m,4), 3.26 (m,2), 2.40 (m,2), 2.30 (m,2), 2.22 (m,2), 1.72 (m,4).

EXAMPLE 10.a.: 4-[N-(Aminocarbonylmethyl)aminocarbonyl]-1-benzyloxycarbonyl-4-(2-oxopiperidino)piperidine. Using a procedure similar to that described in Example 5.a., except replacing

1-benzyloxycarbonyl-4-carboxy-(2-oxoperhydropyrimidin-1-yl)piperidine with 1-benzyloxycarbonyl-4-carboxy-4-(2-oxopiperidino)piperidine and methylamine hydrochloride with glycinamide hydrochloride, and purifying the crude product by chromatography, with dichloromethane:-methanol:ether (gradient 7:1:2, 85:15:0) as eluent, the amide was prepared as a white solid; NMR (CD_3OD): 7.35 (m,5), 5.11 (s,2), 3.91 (m,2), 3.75 (m,2), 3.42 (m,4), 2.35 (m,2), 2.23 (m,2), 1.88 (m,4), 1.75 (m,2).

EXAMPLE 11.a.: 1-Benzyloxycarbonyl-4-[N-(2-methoxycarbonylethyl)-aminocarbonyl]-4-(2-oxopiperidino)piperidine. Using a procedure similar to that described in Example 5.a., except replacing 1-benzyloxycarbonyl-4-carboxy-(2-oxoperhydropyrimidin-1-yl)piperidine with 1-benzyloxycarbonyl-4-carboxy-4-(2-oxopiperidino)piperidine and methylamine hydrochloride with b-alanine methyl ester hydrochloride, and purifying the crude product by chromatography, with dichloromethane:methanol:ether (gradient 8:1:1, 80:20:0) as eluent, the amide was prepared as a foamy, white solid; NMR (CD_3OD): 7.35 (m,5), 5.11 (s,2), 3.89 (m,2), 3.65 (s,3), 3.38 (m,6), 2.52 (m,2), 2.29 (m,2), 2.20 (m,2), 1.85 (m,4), 1.73 (m,2).

EXAMPLE 12.a.: 1-Benzyloxycarbonyl-4-[N-(2-hydroxyethyl)amino-carbonyl]-4-(2-oxopiperidino)piperidine. Using a procedure similar to that described in Example 2.c., except replacing pyrrolidine with ethanolamine, and purifying the crude product by chromatography, with dichloromethane:methanol (90:10) as eluent, the amide was prepared as a foamy, white solid; NMR (CD_3OD): 7.35 (m,5), 5.12 (s,2), 3.90 (m,2), 3.57 (m,2), 3.40 (m,4), 3.28 (m,2), 2.34 (m,2), 2.23 (m,2), 1.88 (m,4), 1.75 (m,2).

EXAMPLE 13.a.: 1-Benzyloxycarbonyl-4-[N-(2-hydroxyethyl)-N-methylaminocarbonyl]-4-(2-oxopiperidino)piperidine. Using a procedure similar to that described in Example 2.c., except replacing pyrrolidine with 2-(methylamino)ethanol, and purifying the crude product by chromatography, with dichloromethane:methanol:ether (4:1:4) as eluent, the amide was prepared as a foamy, white solid; NMR

(CD_3OD): 7.34 (m,5), 5.11 (s,2), 3.99 (m,2), 3.67 (m,2), 3.36 (m,6), 2.96 (m,3), 2.37 (m,2), 2.28 (m,2), 1.85-1.66 (m,6).

EXAMPLE 14.a.: 4-(Aminocarbonyl)-1-benzyloxycarbonyl-4-(2-oxopiperidino)piperidine. Using a procedure similar to that described in Example 2.c., except replacing pyrrolidine with ammonium chloride, and purifying the crude product by chromatographed, with dichloromethane:methanol:ether (4:1:4) as eluent, the amide was prepared as a foamy, white solid; NMR (CD_3OD): 7.35 (m,5), 5.11 (s,2), 3.86 (m,2), 3.40 (m,4), 2.34 (m,2), 2.23 (m,2), 1.86 (m,4), 1.74 (m,2).

EXAMPLES 4.b.-14.b.

Using a procedure similar to that described in Example 2.d., except replacing 1-benzyloxycarbonyl-4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)piperidine with the requisite 1-benzyloxycarbonyl protected piperidine, prepared as described in Examples 4.a.-14.a. above, the following compounds were prepared.

EXAMPLE 4.b.: 4-(2-Oxoperhydropyrimidin-1-yl)-4-(pyrrolidin-1-yl-carbonyl)piperidine; MS: m/z=281(M+1); NMR (CD_3OD): 3.41 (m,6), 3.16 (m,4), 2.98 (m,2), 2.28 (m,2), 2.00-1.78 (m,8).

EXAMPLE 5.b.: 4-(Methylaminocarbonyl)-4-(2-oxoperhydropyrimidin-1-yl)piperidine; MS: m/z=241(M+1); NMR (CD_3OD): 3.41 (m,2), 3.19 (m,2), 3.05 (m,2), 2.89 (m,2), 2.69 (s,3), 2.16 (m,2), 2.00 (m,4).

EXAMPLE 6.b.: 4-(Methylaminocarbonyl)-4-(2-oxopiperidino)piperidine; MS: m/z=240(M+1); NMR (CD_3OD): 3.45 (m,2), 3.10 (m,2), 2.96 (m,2), 2.68 (m,3), 2.32 (m,2), 2.22 (m,2), 1.90 (m,4), 1.75 (m,2).

EXAMPLE 7.b.: 4-(Dimethylaminocarbonyl)-4-(2-oxopiperidino)-piperidine; MS: m/z=254(M+1); NMR (CD_3OD): 3.45 (m,2), 3.09 (m,2), 2.92 (m,8), 2.38 (m,2), 2.26 (m,2), 1.92-1.69 (m,6).

EXAMPLE 8.b.: 4-(Ethylaminocarbonyl)-4-(2-oxopiperidino)piperidine; MS: m/z=240(M+1); NMR (CD_3OD): 3.45 (m,2), 3.17 (q,2, J=7.2), 3.02 (m,2), 2.86 (m,2), 2.31 (m,2), 2.17 (m,2), 1.88 (m,4), 1.75 (m,2), 1.06 (t,3, J=7.2).

EXAMPLE 9.b.: 4-(Benzylaminocarbonyl)-4-(2-oxopiperidino)piperidine; MS: m/z=316(M+1); NMR: 7.26 (m,5), 7.09 (m,1), 4.43 (d,2, J=5.8), 3.33 (m,2), 3.05 (m,2), 2.95 (m,2), 2.80 (m,1), 2.42-2.25 (m,6), 1.73 (m,4).

EXAMPLE 10.b.: 4-[N-(Aminocarbonylmethyl)aminocarbonyl]-4-(2-oxopiperidino)piperidine; MS: m/z=283(M+1); NMR (CD_3OD): 3.76 (m,2), 3.48 (m,2), 3.07 (m,2), 2.91 (m,2), 2.36 (m,2), 2.21 (m,2), 1.90 (m,4), 1.76 (m,2).

EXAMPLE 11.b.: 4-[N-(2-Methoxycarbonylethyl)aminocarbonyl]-4-(2-oxopiperidino)piperidine; MS: m/z=312(M+1); NMR (CD_3OD): 3.65 (s,3), 3.44 (m,2), 3.40 (m,2), 3.08 (m,2), 2.92 (m,2), 2.52 (m,2), 2.30 (m,2), 2.20 (m,2), 1.86 (m,4), 1.75 (m,2).

EXAMPLE 12.b.: 4-[N-(2-Hydroxyethyl)aminocarbonyl]-4-(2-oxopiperidino)piperidine; MS: m/z=270(M+1); NMR (CD_3OD): 3.56 (m,2), 3.46 (m,2), 3.27 (m,2), 3.06 (m,2), 2.90 (m,2), 2.33 (m,2), 2.20 (m,2), 1.89 (m,4), 1.76 (m,2).

EXAMPLE 13.b.: 4-[N-(2-Hydroxyethyl)-N-methylaminocarbonyl]-4-(2-oxopiperidino)piperidine; MS: m/z=284(M+1); NMR (CD_3OD): 3.66 (m,2), 3.45 (m,4), 3.08 (m,2), 2.93 (m,5), 2.38 (m,2), 2.26 (m,2), 1.90-1.70 (m,6).

EXAMPLE 14.b.: 4-(Aminocarbonyl)-4-(2-oxopiperidino)piperidine; MS: m/z=226(M+1); NMR (CD_3OD): 3.45 (m,2), 3.13 (m,2), 2.96 (m,2), 2.34 (m,2), 2.25 (m,2), 1.92 (m,4), 1.74 (m,2).

EXAMPLE 15: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-(methylaminocarbonyl)-4-(2-oxopiperidino)piperidino]butyl]-N-ethylbenzamide citric acid salt.

Using a procedure similar to that described in Example 2, except replacing 4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)-piperidine with 4-(methylaminocarbonyl)-4-(2-oxopiperidino)piperidine and (S)-N-[2-(3,4-dichlorophenyl)-4-oxobutyl]-N-methylbenzamide with (S)-N-[2-(3,4-dichlorophenyl)-4-oxobutyl]-N-ethylbenzamide, the title compound was obtained as a white solid; MS: m/z=587(M+1); Analysis for $C_{31}H_{40}Cl_2N_4O_3 \cdot 1.35\ H_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 55.27; H, 6.35; N, 6.97; Found: C, 55.22; H, 6.22; N, 6.70.

The intermediate (S)-N-[2-(3,4-dichlorophenyl)-4-oxobutyl]-N-ethylbenzamide was prepared as follows.

a. (S)-N-[2-(3,4-Dichlorophenyl)-4-hydroxybutyl]benzamide. Benzoic anhydride (14.6 g) in dichloromethane (50 mL) was added dropwise to a solution of (S)-2-(3,4-dichlorophenyl)-4-hydroxy-butylamine (15.0 g) and triethylamine (9.0 mL) in dichloromethane (200 mL) at 0 °C. After being stirred at 0 °C for 1 hour and then at ambient temperature for 1 hour, the reaction mixture was washed (1 N hydrochloric acid, saturated aqueous sodium bicarbonate), and the separated organic phase was dried and evaporated. The crude product was chromatographed, with dichloromethane:methanol (gradient 98:2, 90:10) as eluent, to give the amide as a light yellow gum (17.5 g); MS: m/z=338(M+1); NMR: 7.65 (m,2), 7.48 (m,1), 7.38 (m,3), 7.33 (d,1, J=2.1), 7.07 (dd,1, J=2.1, 8.2), 6.44 (m,1,NH), 3.83 (m,1), 3.70 (m,1), 3.58-3.41 (m,2), 3.13 (m,1), 2.47 (m,1, OH), 1.99 (m,1), 1.84 (m,1).

b. (S)-N-[4-Acetoxy-2-(3,4-dichlorophenyl)butyl]benzamide. Acetyl chloride (4.6 mL) was added dropwise to a solution of (S)-N-[2-(3,4-dichlorophenyl)-4-hydroxybutyl]benzamide (17.5 g) and pyridine (8.4 mL) in dichloromethane (400 mL) at 0 °C. After being stirred overnight at room temperature, the reaction mixture was washed

(water, saturated aqueous copper(II) sulfate), and the separated organic phase was dried and evaporated to give the acetyl-compound as a light yellow oil; MS: m/z=380(M+1); NMR: 7.63 (m,2), 7.48 (m,1), 7.39 (m,3), 7.32 (d,1, J=2.1), 7.06 (dd,1, J=2.1, 8.2), 6.21 (m,1), 4.03 (m,1), 3.87 (m,2), 3.41 (m,1), 3.07 (m,1), 2.09 (m,1), 1.98 (s,3), 1.92 (m,1).

c. (S)-N-[4-Acetoxy-2-(3,4-dichlorophenyl)butyl]-N-ethylbenzamide. (S)-N-[4-Acetoxy-2-(3,4-dichlorophenyl)butyl]-benzamide (4.2 g) in tetrahydrofuran (15 mL) was cannulated into a suspension of sodium hydride (0.58 g, 60% dispersion in mineral oil) and iodoethane (1.0 mL) in tetrahydrofuran (5 mL). After being stirred overnight, the reaction mixture was concentrated in vacuo, dissolved in dichloromethane, and washed with water. The separated organic layer was dried, evaporated, and chromatographed, with dichloromethane:ether (10:1) as eluent, to give the N-ethyl compound as an oil (3.7 g); MS: m/z=408(M+1).

d. (S)-N-[2-(3,4-Dichlorophenyl)-4-hydroxybutyl]-N-ethyl-benzamide. A solution of (S)-N-[4-acetoxy-2-(3,4-dichlorophenyl)-butyl]-N-ethylbenzamide (3.7 g) in 1 N sodium hydroxide (27 mL), tetrahydrofuran (70 mL), water (20 mL), and methanol (15 mL) was stirred for 3 hours. The reaction mixture was evaporated, dissolved in dichloromethane, and washed with water. The separated organic layer was dried and evaporated to give the alcohol as an oil (3.2 g); MS: m/z=366(M+1).

e. (S)-N-[2-(3,4-Dichlorophenyl)-4-oxobutyl]-N-ethylbenzamide. To a solution of oxalyl chloride (1.3 mL) in dichloromethane (30 mL) at -78 °C was added dimethylsulfoxide (2.1 mL) in dichloromethane (10 mL), followed by (S)-N-[2-(3,4-dichlorophenyl)-4-hydroxybutyl]-N-ethylbenzamide (3.2 g) in dichloromethane (15 mL) within 5 minutes. After 15 minutes, triethylamine (8.2 mL) was added, and the reaction mixture was allowed to warm to ambient temperature. The mixture was diluted with dichloromethane, and washed with dilute aqueous hydrochloric acid, water, and aqueous sodium bicarbonate. The

separated organic layer was dried, evaporated, and chromatographed, with dichloromethane:ether:hexane (2:1:1) as eluent, to give the aldehyde as an oil (2.5 g); MS: m/z=364(M+1).

EXAMPLE 16: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-methoxycarbonyl-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide citric acid salt.

Using a procedure similar to that described in Example 2, except replacing 4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)-piperidine with 4-methoxycarbonyl-4-(2-oxopiperidino)piperidine, the title compound was obtained as a white solid; MS: m/z=574(M+1); Analysis for $C_{30}H_{37}Cl_2N_3O_4 \cdot 1.30\ H_2O \cdot 1.0\ C_6H_8O_7$: Calculated: C, 54.73; H, 6.07; N, 5.32; Found: C, 54.69; H, 5.98; N, 5.36.

The intermediate piperidine was prepared as follows.

a. 1-Benzyloxycarbonyl-4-methoxycarbonyl-4-(2-oxopiperidino)-piperidine. (Trimethylsilyl)diazomethane (17.2 mL, 2.0 M in hexanes) was added dropwise to a stirred suspension of 1-benzyloxycarbonyl-4-carboxy-4-(2-oxopiperidino)piperidine (4.0 g) in methanol (50 mL). After the solution became clear and the yellow color persisted, the reaction mixture was concentrated to an oil in vacuo. The crude product was chromatographed, with dichloromethane:methanol (95:5) as eluent, to give the title compound (4.0 g) as a white solid; MS: m/z=375(M+1); NMR (CD_3OD): 7.35 (m,5), 5.11 (s,2), 3.95 (m,2), 3.66 (s,3), 3.37 (m,2), 3.29 (m,2), 2.32 (m,2), 2.19 (m,2), 1.83 (m,4), 1.72 (m,2).

b. 4-Methoxycarbonyl-4-(2-oxopiperidino)piperidine. Using the procedure of Example 2.d., replacing 1-benzyloxycarbonyl-4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)piperidine with 1-benzyloxy-carbonyl-4-methoxycarbonyl-4-(2-oxopiperidino)piperidine and adding tetrahydrofuran as a cosolvent, the title compound was obtained as an oil; MS: m/z=241(M+1); NMR (CD_3OD): 3.66 (m,3), 3.44 (m,2), 2.93 (m,4), 2.32 (m,2), 2.17 (m,2), 1.86 (m,4), 1.74 (m,2).

EXAMPLE 17: (S)-N-[4-[4-Carboxy-4-(2-oxopiperidino)piperidino]-2-(3,4-dichlorophenyl)butyl]-N-methylbenzamide.

A solution of (S)-N-[2-(3,4-dichlorophenyl)-4-[4-methoxycarbonyl-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide (0.65 g) in tetrahydrofuran (15 mL) and 1.0 N sodium hydroxide (15.5 mL) was heated at reflux overnight. After the tetrahydrofuran was distilled off, the resulting aqueous mixture was adjusted to a pH of 5.5-6.0 and extracted several times with dichloromethane. The organic extracts were dried and evaporated. The crude product was suspended in ether and filtered to give the title compound as a white solid (0.25 g); MS: m/z=560(M+1).

EXAMPLE 18: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-methyl-4-(2-oxo-piperidino)piperidino]butyl]-N-methylbenzamide citric acid salt.

Using a procedure similar to that described in Example 2, except replacing 4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)-piperidine with 4-methyl-4-(2-oxo-piperidino)piperidine, the title compound was obtained as a white solid; MS: m/z=530(M+1); Analysis for $C_{29}H_{37}Cl_2N_3O_2 \cdot 0.80\ H_2O \cdot 1.1\ C_6H_8O_7$: Calculated: C, 56.53; H, 6.31; N, 5.55; Found: C, 56.56; H, 6.24; N, 5.73.

The intermediate piperidine was prepared as follows.

a. 1-Benzyl-4-hydroxy-4-methylpiperidine. 1-Benzyl-4-piperidone (33.5 g) in tetrahydrofuran (500 mL) was added dropwise to a solution of methyllithium (100 mL, 1.4 M in ether), methyllithium lithium bromide complex (93.0 mL, 1.5 M in ether), and methyllithium lithium iodide complex (100 mL, 1.0 M in ether) in tetrahydrofuran (170 mL). After being stirred for 3 hours, the reaction mixture was cooled in an ice bath, quenched with ethanol, and concentrated in vacuo. The resulting residue was dissolved in dichloromethane, washed with water, dried, and evaporated. The crude product was distilled to give the alcohol (34.4 g) as a colorless oil; bp 107-14°C (0.115 mm

Hg); MS: m/z=206(M+1); NMR: 7.28 (m,5), 3.52 (s,2), 2.54 (m,2), 2.37 (m,2), 1.63 (m,4), 1.29 (bs,1), 1.24 (s,3).

b. 4-Acetamido-1-benzyl-4-methylpiperidine. Concentrated sulfuric acid (165 mL, 18 M) was added dropwise to a solution of 1-benzyl-4-hydroxy-4-methylpiperidine (33.9 g) in acetonitrile (190 mL). A white precipitate formed and slowly dissolved. After being stirred overnight, the reaction mixture was poured onto ice, adjusted to pH 10 with 3.0 N sodium hydroxide, and extracted with dichloromethane. The organic extracts were dried and evaporated to give the amide as a white solid (33 g); MS: m/z=247(M+1); NMR: 7.29 (m,5), 5.15 (bs,1), 3.49 (s,2), 2.55 (m,2), 2.22 (m,2), 2.02 (m,2), 1.95 (s,3), 1.66 (m,2), 1.39 (s,3).

c. 4-Amino-1-benzyl-4-methylpiperidine. A solution of 4-acetamido-1-benzyl-4-methylpiperidine (34.0 g) in concentrated hydrochloric acid (340 mL, 12.1 N) was refluxed for 36 hours. The reaction mixture was cooled in an ice bath, and neutralized by the dropwise addition of concentrated sodium hydroxide (163 g in water). The solution was adjusted to pH 10 with additional aqueous sodium hydroxide, and extracted with dichloromethane. The organic extracts were dried and evaporated to give the amine as an amber oil (25.0 g); MS: m/z=205(M+1); NMR (CD_3OD): 7.28 (m,5), 3.52 (s,2), 2.45 (m,4), 1.54 (m,4), 1.10 (s,3).

d. 1-Benzyl-4-(5-chlorovaleramido)-4-methylpiperidine. 5-Chlorovaleryl chloride (4.2 mL) in dichloromethane (20 mL) was added to a solution of 4-amino-1-benzyl-4-methylpiperidine (6.0 g) and pyridine (5.0 mL) in dichloromethane (200 mL) at 0 °C. After being stirred for 1 hour, the reaction mixture was washed with saturated aqueous copper(II) sulfate, dried, and evaporated. The crude product was chromatographed, with dichloromethane:methanol (gradient 98:2, 90:10) as eluent, to give the chloro compound as a white solid (2.4 g); MS: m/z=323(M+1); NMR (CD_3OD): 7.31 (m,5), 3.57 (m,2), 3.54 (s,2), 2.60 (m,2), 2.28 (m,2), 2.16 (m,4), 1.73 (m,4), 1.60 (m,2), 1.32 (s,3).

e. 1-Benzyl-4-methyl-4-(2-oxopiperidino)piperidine. 1-Benzyl-4-(5-chlorovaleramido)-4-methylpiperidine (2.1 g) in tetrahydrofuran (37 mL) was added to a suspension of sodium hydride (0.21 g) in tetrahydrofuran (5 mL). After being refluxed for 2 days, the reaction mixture was quenched with dilute aqueous hydrochloric acid, and evaporated. The residue was dissolved in dichloromethane and washed with saturated aqueous sodium bicarbonate. The organic layer was dried and evaporated to give 1-benzyl-4-methyl-4-(2-oxopiperidino)piperidine as a light orange oil (1.5 g); MS: m/z=287(M+1); NMR (CD_3OD): 7.30 (m,5), 3.51 (s,2), 3.30 (m,2), 2.50-2.29 (m,8), 1.87 (m,2), 1.72 (m,4), 1.33 (s,3).

f. 4-Methyl-4-(2-oxopiperidino)piperidine. Using the procedure of Example 1.o., replacing 1-benzyloxycarbonyl-4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)piperidine with 1-benzyl-4-methyl-4-(2-oxopiperidino)piperidine, the piperidine was obtained as a white solid; MS: m/z=197(M+1); NMR (CD_3OD): 3.33 (m,2), 2.78 (m,4), 2.36 (m,4), 1.79 (m,6), 1.36 (s,3).

EXAMPLE 19: (S)-N-[2-(3,4-Dichlorophenyl)-4-[4-methyl-4-(2-oxoperhydropyrimidin-1-yl)piperidino]butyl]-N-methylbenzamide citric acid salt.

Using a procedure similar to that described in Example 2, except replacing 4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)-piperidine with 4-methyl-4-(2-oxoperhydropyrimidin-1-yl)piperidine, the title compound was obtained as a white solid; MS: m/z=531(M+1); Analysis for $C_{28}H_{36}Cl_2N_4O_2 \cdot 0.50\ H_2O \cdot 1.1\ C_6H_8O_7$: Calculated: C, 55.27; H, 6.14; N, 7.45; Found: C, 55.16; H, 6.17; N, 5.52.

The intermediate piperidine was prepared as follows.

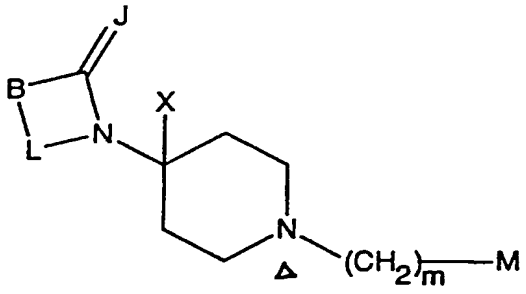
a. 1-Benzyl-4-[N'-(3-chloropropyl)ureido]-4-methylpiperidine. 3-Chloropropyl isocyanate (3.0 mL) in dichloromethane (20 mL) was added to a solution of 4-amino-1-benzyl-4-methylpiperidine (6.0 g) in

dichloromethane (200 mL) at 0 °C. After being stirred overnight, the reaction mixture was evaporated and the resulting material was dissolved in ether. A precipitate formed that was filtered off to give the chloro compound as a white solid (8.9 g); MS: m/z=324(M+1); NMR (CD_3OD): 7.32 (m,5), 3.59 (m,2), 3.56 (s,2), 3.21 (m,2), 2.61 (m,2), 2.35 (m,2), 2.04 (m,2), 1.89 (m,2), 1.60 (m,2), 1.32 (s,3).

b. 1-Benzyl-4-methyl-4-(2-oxoperhydropyrimidin-1-yl)piperidine. Potassium tert-butoxide (33.5 mL, 1.0 M in tert-butanol) was added to a solution of 1-benzyl-4-[N'-(3-chloropropyl)ureido]-4-methylpiperidine (8.3 g) in tetrahydrofuran (62 mL). An additional equivalent of potassium tert-butoxide (25.8 mL, 1.0 M in tert-butanol) was added, and the reaction mixture was stirred overnight. The reaction mixture was evaporated and the resulting residue was dissolved in water (pH 2). The acidic aqueous solution was extracted with dichloromethane (discarded), adjusted to pH 10 with 1.0 sodium hydroxide, and extracted with dichloromethane. The organic extracts were dried, evaporated, and dissolved in ether. A precipitate formed that was filtered off to give the 1-benzyl-4-methyl-4-(2-oxoperhydropyrimidin-1-yl)piperidine as a white solid (3.2 g); MS: m/z=288(M+1); NMR (CD_3OD): 7.30 (m,5), 3.51 (s,2), 3.23 (m,2), 3.15 (m,2), 2.50 (m,4), 2.34 (m,2), 1.82 (m,4), 1.29 (s,3).

c. 4-Methyl-4-(2-oxoperhydropyrimidin-1-yl)piperidine. Using the procedure of Example 1.o., replacing 1-benzyloxycarbonyl-4-(2-oxopiperidino)-4-(pyrrolidin-1-ylcarbonyl)piperidine with 1-benzyl-4-methyl-4-(2-oxoperhydropyrimidin-1-yl)piperidine, the piperidine was obtained as a white solid; MS: m/z=198(M+1); NMR (CD_3OD): 3.26 (m,2), 3.17 (m,2), 2.77 (m,4), 2.44 (m,2), 1.89 (m,2), 1.67 (m,2), 1.31 (s,3).

FORMULAE



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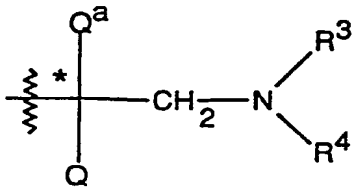

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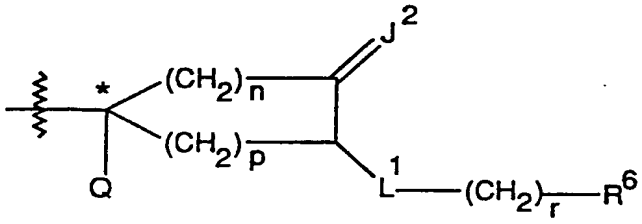

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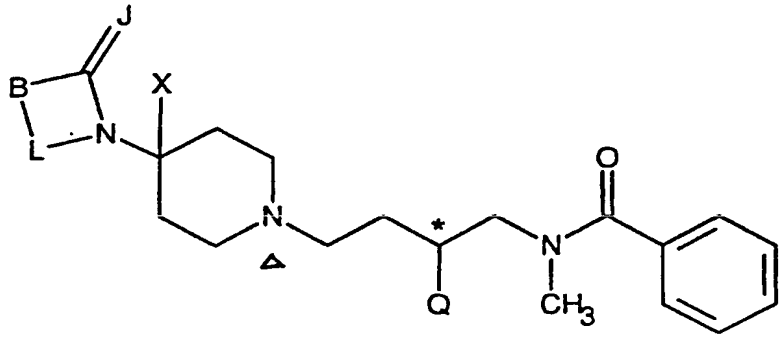

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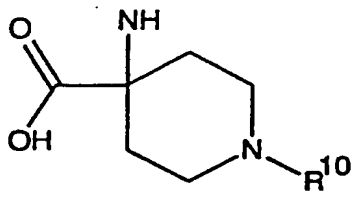

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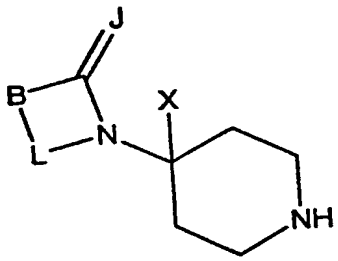

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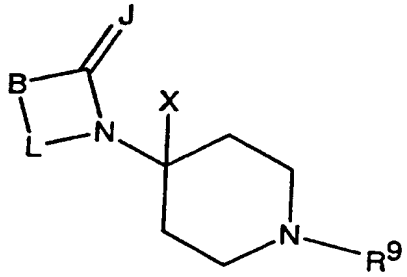

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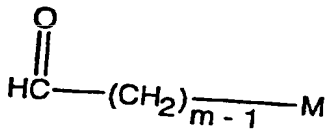

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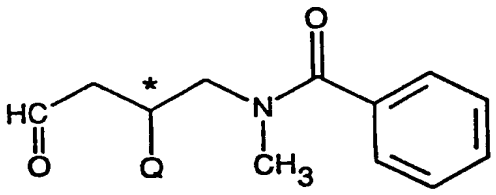

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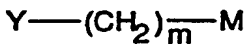

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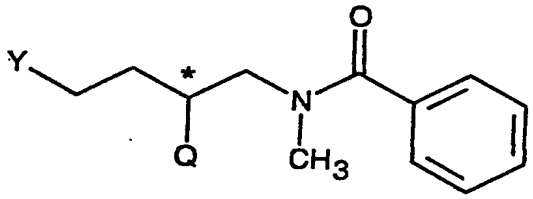

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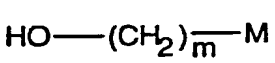

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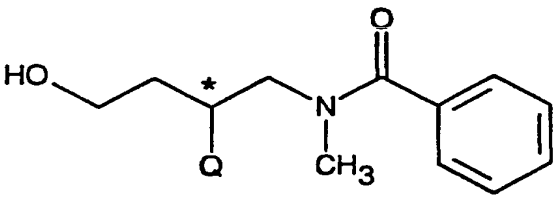
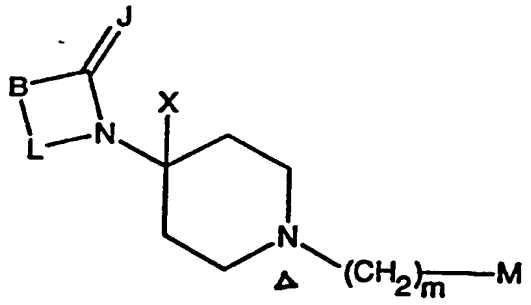


VIc

What is claimed is:

1. A compound of formula I:



(I)

wherein:

X is (1-6C)alkyl, $-CH_2OR^a$, $-CH_2SR^a$, $-CH_2S(=O)R^g$, $-CH_2S(=O)_2R^g$, $-C(=O)R^a$, $-C(=O)OR^a$, $-C(=J^a)NR^bR^c$, $-C(R^a)(OR^d)(OR^e)$, $-CH_2N(R^a)C(=J^a)R^f$, $-CH_2N(R^a)C(=O)OR^f$ or $-CH_2N(R^a)C(=J^a)NR^bR^c$;

B is a direct bond and L is a hydrocarbon chain in which the 1-position is bound to B and L is selected from trimethylene, tetramethylene, cis-1-butenylene and cis,cis-butadienylene; or B is $N(R^h)$ and L is a hydrocarbon chain selected from ethylene, trimethylene and cis-vinylene; or B is N and L is a hydrocarbon chain in which the 1-position is bound to B and L is cis,cis-prop-2-en-1-ylidin-3-yl;

J and J^a are independently oxygen or sulfur;

R^a, R^f and R^h are independently hydrogen or (1-6C)alkyl;

R^b and R^c are independently hydrogen or (1-6C)alkyl in which said (1-6C)alkyl may be substituted by a group selected from hydroxy and (1-3C)alkoxy, or said (1-6C)alkyl may be terminally substituted by a group selected from hydroxy, (1-3C)alkoxy, phenyl, $-C(=O)OR^i$ and $-C(=O)NR^jR^k$; or

R^b and R^c together with the nitrogen to which they are attached form a pyrrolidino, piperidino, morpholino, thiomorpholino (or its S-oxide) or piperazinyl group (which piperazinyl group may bear a methyl or ethyl group at the 4-position);

R^d and R^e are independently (1-3C)alkyl or together form a divalent hydrocarbon chain selected from ethylene and trimethylene;

R^g is (1-6C)alkyl;

R^i, R^j and R^k are independantly hydrogen or (1-3C)alkyl;

Q is phenyl which may bear one or two substituents independently selected from halo, trifluoromethyl, hydroxy, (1-3C)alkoxy, (1-3C)alkyl and methylenedioxy; or Q is thienyl, imidazolyl, benzo[b]thiophenyl or naphthyl any of which may bear a halo substituent; or Q is biphenylyl; or Q is carbon-linked indolyl which may bear a benzyl substituent at the 1-position;

Q^a is hydrogen, (1-4C)alkyl, or a radical of formula $-(CH_2)_q-NR^7R^8$ in which q is 2 or 3 and R^7 and R^8 are independently (1-4C)alkyl or NR^7R^8 is piperidino or 4-benzylpiperidino;

R^3 is hydrogen, methyl or (2-6C)n-alkyl which may bear a terminal amino radical;

R^4 is $-C(=O)R^5$, $-C(=O)OR^5$ or $-C(=J^1)NHR^5$ in which J^1 is oxygen or sulfur and R^5 is hydrogen, (1-6C)alkyl, phenyl(1-3C)alkyl (in which the phenyl may bear one or more halo, hydroxy, (1-4C)alkoxy or (1-4C)alkyl substituents), pyridyl(1-3C)alkyl, naphthyl(1-3C)alkyl, pyridylthio(1-3C)alkyl, styryl, 1-methylimidazol-2-ylthio(1-3C)alkyl, aryl (which may bear one or more halo, hydroxy, (1-4C)alkoxy or (1-4C)alkyl substituents), heteroaryl (which may bear one or more halo, hydroxy, (1-4C)alkoxy or (1-4C)alkyl substituents), or (when R^4 is $-COR^5$) α-hydroxybenzyl;

n is 0, 1, 2 or 3;

p is 1 or 2, and when p is 2, n is 1 and J^2 is two hydrogens;

J^2 is oxygen or two hydrogens;

L^1 is carbonyl or methylene;

r is 0, 1, 2, or 3; and

R^6 is phenyl which may bear one or more halo, trifluoromethyl, (1-4C)alkyl, hydroxy or (1-4C)alkoxy substituents (and particularly one or more chloro or fluoro substituents); naphthyl which may bear one or more halo, trifluoromethyl, (1-4C)alkyl or hydroxy substituents; pyridyl; thienyl; indolyl; quinolinyl; benzothienyl or imidazolyl; or when L^1 is carbonyl, the group $-(CH_2)_r-R^6$ may represent aryl, heteroaryl or a benzyl group bearing an α-substituent selected from hydroxy, (1-4C)alkoxy and (1-4)alkyl, and further wherein the aryl, heteroaryl or phenyl portion of the benzyl group may bear one or more substituents selected independently from halo, trifluoromethyl, (1-4C)alkyl, hydroxy and (1-4C)alkyl, hydroxy and (1-4C)alkoxy (and particularly one or more chloro or fluoro substituents);

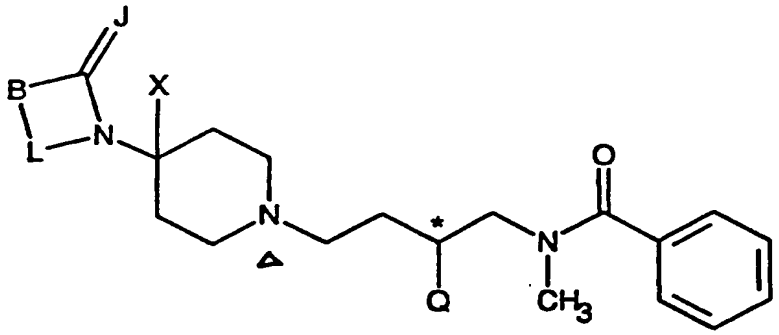
or the N-oxide of the piperidino nitrogen indicated by Δ; or a pharmaceutically acceptable salt thereof; or a quaternary ammonium salt thereof in which the piperidino nitrogen indicated by Δ is a quadricovalent ammonium nitrogen wherein the fourth radical on the nitrogen R^9 is (1-4C)alkyl or benzyl and the associated counterion A is a pharmaceutically acceptable anion.

2. A compound as claimed in claim 1 wherein, R^b and R^c are independently hydrogen or (1-6C)alkyl; or R^b and R^c together with the nitrogen to which they are attached form a pyrrolidino, piperidino, morpholino, thiomorpholino (or its S-oxide) or piperazinyl group (which piperazinyl group may bear a methyl or ethyl group at the 4-position); or the N-oxide of the piperidinio nitrogen indicated by Δ; or a pharmaceutically acceptable salt thereof; or a quaternary ammonium salt thereof.

3. A compound as claimed in claim 1, wherein m is 2; (1-6C)alkyl is methyl, ethyl, propyl, isopropyl or butyl; (1-3C)alkyl is methyl or ethyl; Q is phenyl which may bear one or two substituents selected from halo, trifluoromethyl and methylenedioxy; R^9 is methyl or benzyl; and A is chloride, bromide or methanesulfonate.

4. A compound as claimed in claim 1, wherein M is formula Ib; n is 1 or 2; p is 1; J^2 is two hydrogens; L^1 is carbonyl; r is 0 or 1; and R^6 is phenyl which may bear one or two halo or (1-4C)alkoxy substituents.

5. A compound of formula I as claimed in claim 1, which is a compound of formula Ic:



(Ic)

or the N-oxide of the piperidinio nitrogen indicated by Δ; or a pharmaceutically acceptable salt thereof; or a quaternary ammonium salt thereof; wherein J, B, L, X, Q, R^9 and A have the values defined for a compound of formula I.

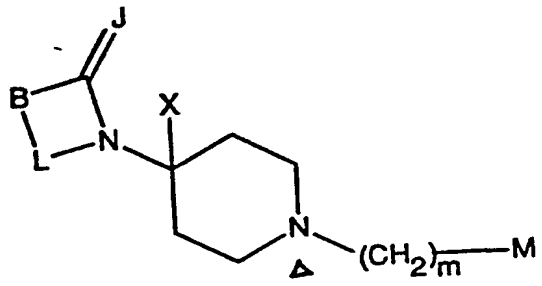
6. A compound as claimed in claim 6 wherein, B is a direct bond and L is a hydrocarbon chain in which the 1-position is bound to B and L is selected from trimethylene, tetramethylene, cis-1-butenylene and cis,cis-butadienylene. or the N-oxide of the piperidinio nitrogen indicated by Δ; or a pharmaceutically acceptable salt thereof; or a quaternary ammonium salt thereof.

7. A compound of formula I as claimed in claim 6, wherein B is $N(R^h)$ and L is a hydrocarbon chain selected from ethylene, trimethylene and cis-vinylene; or B is N and L is a hydrocarbon chain in which the 1-position is bound to B and L is cis,cis-prop-2-en-1-ylidin-3-yl; or the N-oxide of the piperidinio nitrogen indicated by Δ; or a pharmaceutically acceptable salt thereof; or a quaternary ammonium salt thereof.

8. A compound of formula I as claimed in Claim 1, which is selected from, (S)-N-[2-(3,4-dichlorophenyl)-4-[4-(methylamino-carbonyl)-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide; (S)-N-[2-(3,4-dichlorophenyl)-4-[4-(ethylaminocarbonyl)-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide; (S)-N-[2-(3,4-dichlorophenyl)-4-[4-[N-(2-methoxycarbonylethyl)-aminocarbonyl]-4-(2-oxopiperidino)-piperidino]butyl]-N-

methylbenzamide; (S)-N-[4-[4-(aminocarbonyl)-4-(2-oxopiperidino)-piperidino]-2-(3,4-dichlorophenyl)butyl]-N-methylbenzamide; and (S)-N-[2-(3,4-dichlorophenyl)-4-[4-methoxycarbonyl-4-(2-oxopiperidino)piperidino]butyl]-N-methylbenzamide.

9. A pharmaceutical composition comprising a compound of formula I:



(I)

wherein:

X is (1-6C)alkyl, $-CH_2OR^a$, $-CH_2SR^a$, $-CH_2S(=O)R^g$, $-CH_2S(=O)_2R^g$, $-C(=O)R^a$, $-C(=O)OR^a$, $-C(=J^a)NR^bR^c$, $-C(R^a)(OR^d)(OR^e)$, $-CH_2N(R^a)C(=J^a)R^f$, $-CH_2N(R^a)C(=O)OR^f$ or $-CH_2N(R^a)C(=J^a)NR^bR^c$;

B is a direct bond and L is a hydrocarbon chain in which the 1-position is bound to B and L is selected from trimethylene, tetramethylene, cis-1-butenylene and cis,cis-butadienylene; or B is $N(R^h)$ and L is a hydrocarbon chain selected from ethylene, trimethylene and cis-vinylene; or B is N and L is a hydrocarbon chain in which the 1-position is bound to B and L is cis,cis-prop-2-en-1-ylidin-3-yl;

J and J^a are independently oxygen or sulfur;

R^a, R^f and R^h are independently hydrogen or (1-6C)alkyl;

R^b and R^c are independently hydrogen or (1-6C)alkyl in which said (1-6C)alkyl may be substituted by a group selected from hydroxy and (1-3C)alkoxy, or said (1-6C)alkyl may be terminally substituted by a group selected from hydroxy, (1-3C)alkoxy, phenyl, $-C(=O)OR^i$ and $-C(=O)NR^jR^k$; or

R^b and R^c together with the nitrogen to which they are attached form a pyrrolidino, piperidino, morpholino, thiomorpholino (or its S-oxide) or piperazinyl group (which piperazinyl group may bear a methyl or ethyl group at the 4-position);

m is 2 or 3;

M is a residue of formula Ia or formula Ib wherein

Q is phenyl which may bear one or two substituents independently selected from halo, trifluoromethyl, hydroxy, (1-3C)alkoxy, (1-3C)alkyl and methylenedioxy; or Q is thienyl, imidazolyl, benzo[b]thiophenyl or naphthyl any of which may bear a halo substituent; or Q is biphenylyl; or Q is carbon-linked indolyl which may bear a benzyl substituent at the 1-position;

Q^a is hydrogen, (1-4C)alkyl, or a radical of formula $-(CH_2)_q-NR^7R^8$ in which q is 2 or 3 and R^7 and R^8 are independently (1-4C)alkyl or NR^7R^8 is piperidino or 4-benzylpiperidino;

R^3 is hydrogen, methyl or (2-6C)n-alkyl which may bear a terminal amino radical;

R^4 is $-C(=O)R^5$, $-C(=O)OR^5$ or $-C(=J^1)NHR^5$ in which J^1 is oxygen or sulfur and R^5 is hydrogen, (1-6C)alkyl, phenyl(1-3C)alkyl (in which the phenyl may bear one or more halo, hydroxy, (1-4C)alkoxy or (1-4C)alkyl substituents), pyridyl(1-3C)alkyl, naphthyl(1-3C)alkyl, pyridylthio(1-3C)alkyl, styryl, 1-methylimidazol-2-ylthio(1-3C)alkyl, aryl (which may bear one or more halo, hydroxy, (1-4C)alkoxy or (1-4C)alkyl substituents), heteroaryl (which may bear one or more halo, hydroxy, (1-4C)alkoxy or (1-4C)alkyl substituents), or (when R^4 is $-COR^5$) α-hydroxybenzyl;

n is 0, 1, 2 or 3;

p is 1 or 2, and when p is 2, n is 1 and J^2 is two hydrogens;

J^2 is oxygen or two hydrogens;

L^1 is carbonyl or methylene;

r is 0, 1, 2, or 3; and

R^6 is phenyl which may bear one or more halo, trifluoromethyl, (1-4C)alkyl, hydroxy or (1-4C)alkoxy substituents (and particularly one or more chloro or fluoro substituents); naphthyl which may bear one or more halo, trifluoromethyl, (1-4C)alkyl or hydroxy substituents; pyridyl; thienyl; indolyl; quinolinyl; benzothienyl or imidazolyl; or when L^1 is carbonyl, the group $-(CH_2)_r-R^6$ may represent aryl, heteroaryl or a benzyl group bearing an α-substituent selected from hydroxy, (1-4C)alkoxy and (1-4)alkyl, and further wherein the aryl, heteroaryl or phenyl portion of the benzyl group may bear one or more substituents selected independently from halo, trifluoromethyl, (1-4C)alkyl, hydroxy and (1-4C)alkyl, hydroxy

benzothienyl or imidazolyl; or when L^1 is carbonyl, the group $-(CH_2)_r-R^6$ may represent aryl, heteroaryl or a benzyl group bearing an α-substituent selected from hydroxy, (1-4C)alkoxy and (1-4)alkyl, and further wherein the aryl, heteroaryl or phenyl portion of the benzyl group may bear one or more substituents selected independently from halo, trifluoromethyl, (1-4C)alkyl, hydroxy and (1-4C)alkyl, hydroxy and (1-4C)alkoxy (and particularly one or more chloro or fluoro substituents);

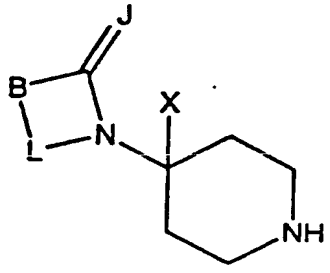
or the N-oxide of the piperidino nitrogen indicated by Δ;

or a pharmaceutically acceptable salt thereof;

or a quaternary ammonium salt thereof in which the piperidino nitrogen indicated by Δ is a quadricovalent ammonium nitrogen wherein the fourth radical on the nitrogen R^9 is (1-4C)alkyl or benzyl and the associated counterion A is a pharmaceutically acceptable anion; and a pharmaceutically acceptable diluent or carrier.

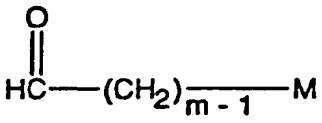
10. A process for the manufacture of a compound of formula I; or the N-oxide of the piperidino nitrogen indicated by Δ; or a pharmaceutically acceptable salt thereof; or a quaternary ammonium salt thereof in which the piperidino nitrogen indicated by Δ is a quadricovalent ammonium nitrogen wherein the fourth radical on the nitrogen R^9 is (1-4C)alkyl or benzyl and the associated counterion A is a pharmaceutically acceptable anion; as defined in any one of claims 1-8, which is characterized by:

(a) Alkylating a piperidine of formula III:



(III)

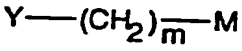
with an aldehyde of formula IV:



(IV)

by reductive alkylation;

(b) Alkylating a piperidine of formula III with an alkylating agent of formula V,

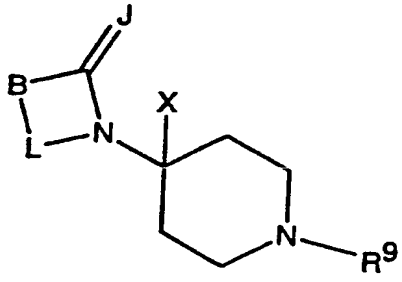


(V)

in which Y is a leaving group;

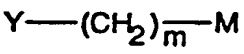
(c) For an N-oxide of the piperidino nitrogen indicated by Δ of a compound of formula I, oxidizing the piperidino nitrogen indicated by Δ of a compound of formula I;

(d) For a quaternary ammonium salt of a compound of formula I, alkylating the piperidino nitrogen indicated by Δ of the compound of formula I; or alkylating a piperidine of formula IIIa:



(IIIa)

with an alkylating agent of formula V:



(V)

wherein Y is a leaving group, followed, if required, by exchanging the counterion Y for a different counterion A; or

(e) for a compound of formula I wherein X is defined as $-C(=O)OR^a$ and R^a is hydrogen, hydrolyzing a corresponding compound of formula I wherein R^a is (1-6C)alkyl.

INTERNATIONAL SEARCH REPORT

Intc. ..ional Application No
PCT/GB 94/02382

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C07D211/76 C07D401/04 A61K31/445

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C07D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	WO,A,94 10146 (ZENECA) 11 May 1994 cited in the application see example 7	1-10
A	EP,A,0 512 901 (ELF SANOFI) 11 November 1992 cited in the application see the whole document	1-10
A	EP,A,0 428 434 (SANOFI) 22 May 1991 cited in the application see the whole document	1-10

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
3 February 1995	20. 02. 95

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Kissler, B

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. ational Application No
PCT/GB 94/02382

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO-A-9410146	11-05-94	AU-B-	5374294	24-05-94
		ZW-A-	13893	27-07-94
EP-A-0512901	11-11-92	FR-A-	2676055	06-11-92
		AU-B-	652046	11-08-94
		AU-A-	1591692	05-11-92
		JP-A-	5186425	27-07-93
		US-A-	5340822	23-08-94
EP-A-0428434	22-05-91	FR-A-	2654100	10-05-91
		FR-A-	2663329	20-12-91
		AU-B-	5924594	02-06-94
		AU-B-	649973	09-06-94
		AU-A-	6583890	23-05-91
		CA-A-	2029275	07-05-91
		JP-A-	3206086	09-09-91
		US-A-	5317020	31-05-94